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MODERN MECHANICAL SCIENCE.

From the inaugural address of C. W. Siemens, F. R. S., before Section G (Mechanical Science Section) of the British Association, August 19, 1869.

In prefacing our proceedings with a few remarks on the leading subjects of the day of special interest to our section, I can scarcely pass over the somewhat hackneyed question of technical education.

Technical Education.—The great international exhibitions proved, that although England still holds her ground as the leading manufacturing country, the nations of the Continent have made great strides to dispute her pre-eminence in several branches, a result which is generally ascribed to their superior system of technical education. Those desirous of obtaining a clear insight into that system, and the vast scale upon which it is being carried out under Government supervision, cannot do better than read Mr. John Scott Russell's very able volume on this subject, and they will, no doubt, agree with the author in the necessity of energetic steps being taken in this country to promote the work of universal education. Although I, for one, think that objection may fairly be made against the plan of merely imitating the example of our neighbors.

The polytechnic schools of the Continent, not satisfied to impart to the technical student a good knowledge of mathematics and of natural sciences, pretend, also, to superadd the practical information necessary to constitute them engineers or manufacturers.

This practical information is conveyed to them by professors, lacking themselves practical experience, and tends to engender in the students a dogmatical conceit, which is likely to stand in the way of originality in the adaptation of new means to new ends in their future career. On this account, I should prefer to see a sound "fundamental" education, comprising mathematics, dynamics, chemistry, geology and physical science, with a sketch only of the technical arts, followed up by professional training, such as can only be obtained in the workshop, the office or the field.

Patents.—Closely allied to the question of education is that of the system of Letters Patent. A patent is, according to modern views, a contract between the Commonwealth and an individual who has discovered a method, peculiar to himself, of accomplishing a result of general utility. The State, being interested to secure the information, and to induce the inventor to put his invention into practice, grants him the exclusive right of practising it, or of authorizing others to do so, for a limited number of years, in consideration of his making a full and sufficient description of the same. Unfortunately, this simple and equitable theory of the patent system is very imperfectly carried out, and is beset with various objectionable practices, which render a patent sometimes an impediment to, rather than a furtherance of applied science, and sometimes involves the author of an invention in endless legal contentions and disaster, instead of procuring for him the intended reward. These evils are so great and palpable, that many persons, including men of undoubted sincerity and sound judgment on most subjects, advocate the entire abolition of the Patent Laws. They argue that the desire to publish the results of our mental labor suffices to ensure to the Commonwealth

the possession of all new discoveries or inventions, and that justice might be done to meritorious inventors by giving them national rewards.

This argument may hold good as regards a scientific discovery, where the labor bestowed is purely mental, and carries with it the pleasurable excitement peculiar to the exercise and advancement of science on the part of the devotee; but a practical invention has to be regarded as the result of a first conception, elaborated by experiments and their application to existing processes in the face of practical difficulties, of prejudice, and of various discouragements, involving also great expenditure of time and money, which no man can well afford to give away, nor can men of merit be expected to advocate their cause before the national tribunal of rewards, where at best only very narrow and imperfect views of the ultimate importance of a new invention would be taken, not to speak of the favoritism to which the doors would be thrown open. Practical men would undoubtedly prefer either to exercise their inventions in secret, where that is possible, or to desist from following up their ideas to the point of their practical realization. If we review the progress of the technical arts of our time, we may trace important practical inventions almost without exception to the Patent Office. In cases where the inventor of a machine or process, happened to belong to a nation without an efficient patent law, we find that he readily transferred the scene of his activity to the country offering him the greatest encouragement, there to swell the ranks of intelligent workers. Whether we look upon the powerful appliances that fashion shapeless masses of iron and steel into railway wheels or axles, or into the more delicate parts of machinery; whether we look upon the complex machinery in our cotton factories, our dye works and paper mills, or into a Birmingham manufactory, where steel pens, buttons, pens, buckles, screws, pencil-cases, and other objects of general utility are produced by carefully elaborated machinery, at an extremely low cost; or whether we look upon our agricultural machinery, by which England is enabled to compete, without protection, against the Russian or Danubian agriculturist, with cheap labor and cheap land to back him, in nearly all cases we find that the machine has been designed and elaborated in its details by a patentee who did not rest satisfied till he had persuaded the manufacturers to adopt the same, and removed all their real or imaginary objections to the innovation. We also find that the knowledge of its construction reaches the public directly or indirectly through the Patent Office, thus enlarging the basis for further inventive progress.

The greatest illustration of the beneficial working of the patent laws, was supplied, in my opinion, by James Watt, when, just about 100 years ago, he patented his invention of a hot working cylinder and separate steam engine condenser. After years of contest against those adverse circumstances that beset every important innovation, James Watt, with failing health and scanty means, was only upheld in his struggle by the deep conviction of the ultimate triumph of his cause. This conviction gave him confidence to enlist the co-operation of a second capitalist, after the first had failed him, and of asking for an extension of his declining patent.

Without this opportune help Watt could not have succeeded to mature his invention; he would, in all probability, have relapsed into the mere instrument maker, with broken health and broken heart, and the invention of the steam engine would not only have been retarded for a generation or two, but its final progress would have been based probably upon the coarser conceptions of Papin, Savory and Newcomen.

It can easily be shown that the perfect conception of the physical nature of steam, which dwelt like a Heaven-born inspiration in Watt's mind, was neither understood by his contemporanies nor by his followers, up to very recent times; nor can it be gathered from Watt's very imperfect specification. James Watt was not satisfied to exclude the condensing water from his working cylinder, and to surround the same by non-conducting substances, but he placed between the cylinder and the non-conducting envelope, a source of heat in the form of a steam jacket, filled with steam at a pressure somewhat superior to that of the working steam. His successors have not only discarded the steam jacket, and even condemned it on the superficial plea that the jacket presented a larger and hotter surface for loss by radiation than the cylinder, but expansive working was actually rejected by some of them on the ground that no practical advantage could be obtained by it. The modern engine, notwithstanding our perfected means of construction, had in fact degenerated in

many instances into a simple steam-meter, constructed apparently with a view of emptying the boiler in the shortest possible space of time.

It is only during the last twenty years that the subtile action of saturated steam in condensing upon the sides of the cylinder when under pressure, and of evaporating when the pressure is relieved toward the end of each stroke, has been again recognized and insisted upon by Lechatelier and others, who have shown the necessity of a slightly super-heated cylinder in order to realize the expansive force of steam.

The result has been a reduction in the consumption of fuel in our best marine engines from 6 to 8 to below 3 lbs. per gross indicated horse power.

Would it be safe in view of such facts as these to discard the patent laws which, as I have endeavored to show, lay at the very foundation of our modern progress, without making at all events a serious effort to remedy those evils, which, it is admitted on all hands, now adhere to them? These evils need for the most part no special legislation, but can be traced to the imperfect manner in which the existing patent laws are carried into effect.

It is a hopeful circumstance that during the next session of Parliament, the whole question of the patent laws is likely to be inquired into by a special committee, who, it is to be hoped, will act decidedly in the general interest, without being influenced by special or professional claims. They will have it in their power to render the Patent Office an educational institution of the highest order.

The Great Works of the Year.—In viewing the latest achievements of engineering science, two works strike the imagination chiefly by their exceeding magnitude, and by the influence they are likely to exercise upon the traffic of the world. The first of these is the great Pacific Railway, which, in passing through vast regions hitherto inaccessible to civilized man, and over formidable mountain chains, joins California with the Atlantic States of the great American republic. The second is the Suez shipping canal, which, notwithstanding adverse prognostications and serious difficulties, will be opened very shortly to the commerce of the world. These works must greatly extend the range of commercial enterprise in the North Pacific and the Indian Seas. The new waterway to India, will, owing to the difficult navigation of the Red Sea, be in effect only available for ships propelled by steam, and will give a stimulus to that branch of engineering.

Telegraphs.—Telegraph communication with America has been rendered more secure against interruption by the successful submersion of the French Transatlantic Cable. On the other hand, telegraphic communication with India still remains in a very unsatisfactory condition, owing to imperfect lines and divided administration.

To supply a remedy for this public evil, the Indo-European Telegraph Company will shortly open its special lines for Indian correspondence. In Northern Russia, the construction of a land line is far advanced to connect St. Petersburg with the mouth of the Amour river, on completion of which only a submarine link between the Amour and San Francisco will be wanting to complete the telegraphic girdle round the earth.

With these great highways of speech once established, a network of submarine and aërial wires will soon follow, to bind all inhabited portions of our globe together into a closer community of interests, which, if followed up by steam communication by land and by sea, will open out a great and meritorious field for the activity of the civil and mechanical engineer.

Railways.—But while great works have to be carried out in distant parts, still more remains to be accomplished nearer home. The railway of to-day has not only taken the place of high roads and canals, for the transmission of goods and passengers between our great centers of industry and population, but is already superseding by-roads leading to places of inferior importance; it competes with the mule in carrying minerals over mountain passes, and with the omnibuses in our great cities. If a river cannot be spanned by a bridge without hindering navigation, a tunnel is forthwith in contemplation; or, if that should not be practicable, the transit of trains is yet accomplished by the establishment of a large steam ferry.

It is one of the questions of the day to decide by which plan the British Channel should be crossed, to relieve the unfortunate traveler to the Continent of the exceeding discomfort and delay inseparable from the existing most imperfect arrangements. Considering that this question has now been taken up by some of our leading engineers, and is also entertained by the two interested

Governments, we may look forward to its speedy and satisfactory solution.

So long as the attention of railway engineers was confined to the construction of main lines, it was necessary for them to provide for a heavy traffic and high speeds, and these desiderata are best met by a level, permanent way, by easy curves, and heavy rails of the strongest possible materials, namely, cast steel, but in extending the system to the corners of the earth, cheapness of construction and maintenance, for a moderate speed, and a moderate amount of traffic, become a matter of necessity.

Instead of plunging through hill and mountain, and of crossing and recrossing rivers by a series of monumental works, the modern railway passes in zigzag up the steep incline, and conforms to the windings of the narrow gorge; it can only be worked by light rolling stock of flexible construction, furnished with increased power of adhesion and great brake power. Yet, by the aid of the electric telegraph, in regulating the progress of each train, the number of trains may be so increased as to produce, nevertheless, a large aggregate of traffic, and it is held by some that our trunk lines even would be worked more advantageously by light rolling stock.

The brake power on several of the French and Spanish railways has been greatly increased by an ingenious arrangement, conceived by M. Lechatelier, of applying what has been termed "contre vapeur" to the engine, converting it for the time being into a pump forcing steam and water into the boiler.

Warfare.—While the extension of communication occupies the attention of perhaps the greater number of our engineers, others are engaged upon weapons of offensive and defensive warfare. We have scarcely recovered our wonder at the terrific destruction dealt by the Armstrong gun, the Whitworth bolt, or the steel barrel consolidated under Krupp's gigantic steam hammer, when we hear of a shield of such solidity and toughness, as to bid defiance to them all. A larger gun, or a hard bolt by Palliser or Gruson, is the successful answer to this challenge, when again defensive plating, of greater tenacity to absorb the power residing in the shot, or of such imposing weight and hardness combined as to resist the projectile absolutely (causing it to be broken up by the force residing within itself), is brought forward.

The ram of war with heavy iron sides, which a few years since was thought the most formidable, as it certainly was the most costly weapon ever devised, is already being superseded by vessels of the Captain type, as designed by Captain Coles, and ably carried out by Laird Brothers, with turrets (armed with guns of gigantic power) that resist the heaviest firing, both on account of their extraordinary thickness, and of the angular direction in which the shot is likely to strike.

By an ingenious device Captain Moncrieff lowers his gun upon its rocking carriage after firing, and thereby does away with embrasures (the weak place in protecting works), while at the same time he gains the advantage of reloading his gun in comparative safety.

It is presumed that in thus raising formidable engines of offensive and defensive warfare, the civilized nations of the earth will pause before putting them into earnest operation, but if they should do so, it is consolatory to think that they could not work them for long without effecting the total exhaustion of their treasuries, already drained to the utmost in their construction.

Iron and Steel.—While science and mechanical skill combine to produce these wondrous results, the germs of further and still greater achievements are matured in our mechanical workshops, in our forges, and in a metallurgical smelting works; it is there that the materials of construction are prepared, refined and put into such forms as to render greater and still greater ends attainable. Here a great revolution of our constructive art has been prepared by the production, in large quantities, and at moderate cost, of a material of more than twice the strength of iron, which, instead of being fibrous, has its full strength in every direction, and which can be modulated to every degree of ductility, approaching the hardness of the diamond on the one hand, and the proverbial toughness of leather on the other. To call this material cast steel seems to attribute to it brittleness and uncertainty of temper, which, however, are by no means its necessary characteristics. This new material, as prepared for constructive purposes, may, indeed, be both hard and tough, as is illustrated by the hard steel rope that has so materially contributed to the practical success of steam ploughing. Machinery steel has gradually come into use since about 1850, when Krupp, of Essen, commenced to

supply large ingots that were shaped into railway tyres, axles, cannon, &c., by melting steel in furnaces containing hundreds of melting crucibles.

The Bessemer process, in dispensing with the process of puddling, and in utilizing the carbon contained in the pig iron to effect the fusion of the final metal, has given a vast extension to the application of cast steel for railway bars, tyres, boiler plates, &c.

The process is limited, however, in its application to superior brands of pig iron, containing much carbon, and no sulphur or phosphorus, which latter impurities are so destructive to the quality of steel. The puddling process has still to be resorted to, to purify these inferior pig irons, which constitute the bulk of our productions, and the puddled iron cannot be brought to the condition of cast steel except through the probess of fusion. This is accomplished successfully in masses of from 3 to 5 tons on the open bed of a regenerative gas furnace, at the Landore Siemens Steel Works, and at other places. At the same works cast steel is also produced, to a limited extent as yet, from iron ore, which, being operated upon in large masses, is reduced to the metallic state, and liquified by the aid of a certain proportion of pig metal. The regenerative gas furnace, the application of which, to glass houses, to forges, &c., has made considerable progress, is unquestionably well suited for this operation, because it combines an intensity of heat, limited only by the point of fusion of the most refractory material, with extreme mildness of draught and chemical neutrality of flame.

These and other processes of recent origin, tend toward the production, at a comparatively cheap rate, of a very high class material, that must shortly supersede iron for almost all structural purposes. As yet engineers hesitate, and very properly so, to construct their bridges, their vessels, and their rolling stock, of the material produced by these processes, because no exhaustive experiments have been published as yet, fixing the limit to which they may safely be loaded in extension, in compression and in torison, and because they have as yet no sufficient information regarding the tests by which their quality can best be ascertained. This great want is in a fair way of being supplied by the experimental researches that have been carried on for some time at Her Majesty's dockyards at Woolwich, under a committee appointed for that purpose by the Institution of Civil Engineers. In the meantime excellent service has been rendered by Mr. Kirkaldy, in giving us, in a perfectly reliable manner, the resisting power and ductility of any sample of material which we wish to submit to his tests. The results of Mr. Whitworth's experiments, tending to render the hammer and the rolls obsolete, by forcing cast steel, while in a semi-fluid state, into strong iron moulds by hydraulic pressure, are looked upon with great interest. But assuming that the new building material has been reduced to the utmost degree of uniformity and cheapness, and that its limits of strength are fully ascertained, there remains still the task for the civil and mechanical engineer to prepare designs suitable for the development of its peculiar qualities. If in constructing a girder, for example, a design were to be adopted that had been worked out for iron, and if all the scantlings were simply reduced in the inverse proportion of the absolute and relative strength of the new material as compared with iron, such a girder would assuredly collapse when the test weight was applied, for the simple reason that the reduced sectional area of each part, in proportion to its length, would be insufficient to give stiffness. You might as well almost take a design for a wooden structure, and carry it out in iron, by simply reducing the section of each part. The advantages of using the stronger material become most apparent, if applied, for instance, to large bridges, where the principal strain upon each part is produced by the weight of the structure itself; for supposing that the new material can be safely weighted to double the bearing strain of iron, and that the weight of the structure were reduced by one-half accordingly, there would still remain a large excess of available strength, in consequence of the reduced total weight, and this would justify a further reduction of the amount of the material employed. In constructing works in foreign parts, the reduced cost of carriage furnishes also a powerful argument in favor of the stronger material, although its price per ton might largely exceed that of iron.

Coal and Power.—The inquiries of the Royal Commission into the extent and management of our coalfields, appear to be reassuring as regards the danger of their becoming soon exhausted; nevertheless, the importance of economizing these precious deposits in the production of steam power

in metallurgical operations, and in domestic use, can hardly be overestimated. The calorific power residing in a pound of coal of a given analysis, can now be accurately expressed in units of heat, which again are represented by equivalent units of force, or of chemical action; therefore, if we ascertain the consumption of coal of a steam engine, or of a furnace employed in metallurgical operations, we are able to tell by the light of physical science, what proportion of the heat of combustion is utilized, and what proportion is lost. Having arrived at this point, we can also trace the channels through which loss takes place, and in diminishing these by judicious improvement, we shall more and more approach those standards of ultimate perfection which we can never reach, but which we should nevertheless keep steadfastly before our eyes. Thus a pound of ordinary coal is capable of producing 12,000 Fahrenheit units of heat, which equal 9,264,000 foot-pounds or units of force, whereas the very best performances of our pumping engines do not exceed the limit of 1,000,000 foot-pounds of force per pound of coal. In like manner 1 lb. of coal should be capable of heating 33 lbs. of iron to the welding point of say 3000° Fahr., whereas in an ordinary furnace not 2 lbs. of iron are so heated with 1 lb. of coal. These figures serve to show the great field for further improvement that lays yet before us.

Refrigeration.—Although heat may be said to be the moving principle by which all things in nature are accomplished, an excess of it is not only hurtful to some of our processes, such as brewing, and destructive to our nutriments, but to those living in hot climates, or sitting in crowded rooms, an excess of temperature is fully as great a source of discomfort as excessive cold can be. Why, then, may I ask, should we not resort to refrigeration in summer, as well as to calorification in winter, if it can be shown that the one can be done at nearly the same cost as the other? So long as we rely for refrigeration upon our ice cellars, or upon importation of ice from distant parts, we shall have to look upon refrigeration as a costly luxury only, but by the use of properly constructed machines it will be possible, I believe, to produce refrigeration at an extremely moderate expenditure of fuel and labor. A machine has already been constructed capable of producing 9 lbs. of ice or its equivalent for 1 lb. of coal, whereas the equivalent values of positive heat developed in the combustion of 1 lb. of coal, and of negative heat residing in 1 lb. of ice, is about as 12,000 to 170, or as 1 to 70. This result already justifies the employment of refrigerating machines upon a large scale, but it is hard to say what practical results may yet be reached with an improved machine on strictly dynamical principles, because such a machine seems not tied in its results to any definite limits. In changing, for instance, a pound of water from the liquid into the gaseous state, a given number of units of heat are required, that may be produced by combustion of coal or by the expenditure of force, but in changing the same pound of water into ice, heat is not lost but gained in the oporation, which heat must be traceable to another part of the machine, either as sensible heat or as developed force. It would lead me too far to enter at present into particulars on this question, which is one not without interest for the physicist and the mechanical engineer.

SEA COAST DEFENSE.

THE MONCRIEFF SYSTEM OF WORKING ARTILLERY.

From a paper by Captain MONCRIEFF, before the Royal Institution of Great Britain.

Until the time of the Crimean war very little and very slow progress had been made in artillery. Canon were manufactured on nearly the same models, and of the same materials, that had been used for 300 years. Before that time cast-iron was not in use, but the forged or bronze guns, although in some cases large, were not what is now considered powerful, and the penetration of their shot was not sufficient to pass through a parapet of earth that is now pierced even by light rifled artillery. The conditions, therefore, under which artillery was worked, and the means provided for protection against its fire, remained much the same as they were in the time of Vauban. Several events during the Crimean campaign confirmed an impression that has always been more or less entertained—that an increase in the power of individual guns produced greater results than could be obtained by a much greater weight of metal, distributed among a larger number of small pieces of artillery. It is not too much to say that the development of this art has, since 1855, changed the character of war both on land and water. It has established completely the superiority

of a few large pieces over a much greater weight of metal in smaller guns. It has given artillery of all classes a range, penetration, and an accuracy of *Fire*, which throw into the shade the greatest results that had been previously obtained. It has also stimulated the advocates of cast-iron smooth bores to produce guns that might rival the rifled artillery; and yet it is by no means probable that the limit of power, either of large smooth-bores or rifled guns, has been arrived at. When it became apparent that mighty results were to be obtained from improved artillery, a great deal of engineering talent was directed to the subject. Comparatively new appliances, such as the steam-hammer, and new methods of working steel, were called to aid in the construction of the new and powerful guns. So much interest, indeed, was taken in the subject, and so much attention absorbed by it, that the conditions which these improvements in artillery themselves imported with them ran some danger of being neglected. The power of artillery became so great that the ordinary provisions for protection against its fire were rendered useless. Forts that were considered strong twenty years ago would crumble under the shock of modern projectiles, and in some cases would be even too weak to support the guns while they were fired. That service which the new artillery affected most palpable was the Navy, and the Navy accordingly took the initiative in introducing means calculated to resist the penetration of the new and terrible projectiles. Every one is more or less conversant with the process that has been going on of covering ships' sides with iron, which has increased in thickness till it really looks as if the process at last would only be limited by a ship's power of flotation. Warships, however, not only protect their sides against shot, but they also carry the heaviest artillery on their decks. This fact could not be overlooked by those who had to construct coast defenses, as well as other works against which modern heavy artillery might be used.

I shall not enter into details regarding the successive steps which were taken in England in this direction, as I understand Colonel Jervoise has already done so in this Institution. It is enough to state that great engineering skill has been exercised, and unwearied efforts have been made to meet the new conditions. That skill and these efforts have, with the experiments at Shoeburyness, given us defensive iron structures which are marvels of strength and ingenuity. Unfortunately they are also marvels of costliness; and there is room to hope that their use will therefore be generally confined to such positions on *land* as can only be protected by such iron structures. This hope is founded on another system, with which my name is connected, and which I am here to explain. Before doing so I shall point out the dilemma which left military engineers no alternative, and which compelled them to give up in succession the use of earth, concrete, granite, etc., and at last to resort to the most expensive, but the strongest, material—*iron*.

There are two considerations always to be taken into account in providing the means of using artillery: the one is to place the gun so as to be most formidable to the enemy, and the other is to place it at the same time under as much cover as possible, so that it is not liable to be disabled, nor are the men serving it liable to be destroyed by hostile fire. These two conditions interfere with one another; that is to say, whatever has hitherto been gained in one direction has been lost in the other. Guns, *en barbette*, lack protection; guns in embrasures or in casemates sacrifice, on the other hand, free lateral range, and it is more difficult in their case to see the enemy, and therefore to lay the guns in action. The difficulty that presented itself with the introduction of late improvements in artillery was simply that the increased precision and range, coupled with great improvements in the manufacture of large shells and also in small arms, rendered barbette batteries too exposed to be relied on. At the same time the tremendous penetration and precision of the new artillery rendered the ordinary parapet and embrasures useless. What was to be done under these circumstances? Protection from direct fire must be got at any price. The first impulse would be to thicken the parapet. This could not, however, be done, as the necessary angle in the cheeks of the embrasures required for training the guns opens up a wider aperture, in direct proportion to the thickness of the parapet, making the *maximum* thickness in practice 30 ft. But shot have been known to penetrate more than 30 ft. into the earth; and the most important part of the parapet, viz: that near the guns, must always be thin and weak, whatever may be the thickness of the rest. Shells, striking this part,

would just meet sufficient resistance to burst them, and would make havoc among the men. Next, granite masonry was thought of; but it proved in some respects worse than earth, and was found practically bad; there was no alternative but to go to iron. This conclusion was reluctantly arrived at, and reluctantly it was acted on.

The decisions of committees which investigated all the bearings of the question, the opinions of professional men and the experiences of the American war, all coincided, and accordingly our important coast-works were designed to receive *iron* shields, casemates and cupolas. Vital positions in England, such as dockyards and arsenals, must be fortified. It would be false economy, indeed, to use any method of fortification that experience has proved to be insufficient. *No savings* could justify the erection of works that might prove at once the tomb of their defenders and perhaps of the nation's honor. Therefore the only proper decision was to take that means to meet the difficulty which was at the time considered best and safest. Expense was properly a consideration very secondary in importance to efficiency.

I shall now endeavor to point out the difficulty of the task which lay before the engineer, even after the decision in favor of iron, from the extraordinary advances, already spoken of, in artillery. There is only one morsel of comfort left for those who have to provide for the requirements of defense, viz: that a form of artillery fire of a very galling nature remains exactly as before, and indeed is not much better, than it was in the time of Queen Elizabeth. What is alluded to is vertical or mortar fire. There is some consolation, too, in the reflection that the cause of this fire not being much improved is one to a great extent likely to be lasting. Rifled mortars would no doubt lessen deflection to right or left; but as long as gunpowder is affected in strength by the slightest atmospheric or other influence, and still more certainly as long as a slight error in elevation at long ranges will make a large error on the plane of fire, the comparative inaccuracy of vertical fire must continue. To show how little can be done in this way compared with the admirable precision and accuracy of direct fire, I may state that 100 rounds were fired one day last season at Shoeburyness at 800 yards range, with a 13-in. mortar, at the row of experimental casemates, which cover a good deal of ground. The mortar was laid with spirit-levels and all the appliances of the school of gunnery, and yet the 100 rounds were expended without a single hit. If such is the case with a steady platform and under such exceptionably favorable circumstances, it can easily be seen how uncertain in its effects would practice be from mortar-boats, which move with every wave, if directed at an equally small object. During the eleven months' siege of Sebastopol the French had 242 mortars engaged, which were themselves exposed to vertical fire, and yet not one of these mortars was disabled. It is indeed a strange contrast—that while direct fire is getting more powerful, more accurate and more destructive every year, vertical fire remains much as it was, and can only be relied on to hit a large object, such as a fort, a town, or anything that covers a good deal of ground. Notwithstanding this, it would be a great mistake to despise it as a powerful and galling means of attack.

To return to the difficulties of meeting direct fire in coast defense. It must be borne in mind that the batteries intended to engage ships are obliged to meet an enemy who can move his position to that quarter where he is least exposed, who can continue in motion while he is conducting his attack, and who can seek out the most vulnerable face of the land-work to operate upon. In constructing such batteries it is first of all necessary to make them of sufficient strength to resist the guns of ships which are the most powerful that can be made. It is next required that these batteries should be constructed in such a manner that they can direct their fire with rapidity and precision in any direction in which the ships can take up their position. And lastly, it is required that they should mount guns of sufficient weight and power to be formidable to the heaviest iron-clads.

In former times guns *en barbette* were preferred for this purpose, because they met the two first requirements alluded to; that is to say, that from not being confined by embrasures or ports, they were able freely to follow their floating enemy, whatever position he might take up; naval fire at that time being neither so correct nor so formidable as to make such batteries unserviceable. The case, however, is now completely changed; for not only have guns been improved, but ammunition also, and heavy shells are most destructive. Rear-Admiral Porter, of the United States Navy, in a report on coast defenses, says: "Such

guns, *standing so high up*, are just the objects that naval gunners would delight to explode their shrapnel against, and, from my experience in naval gunnery, the third shell would kill every man at the gun." Von Scheliha, in his treatise on coast defenses, "Guns mounted *en barbette* may always be silenced by an iron-clad." This form of battery, therefore, is disposed of. We shall now examine the difficulties connected with the other alternatives. Common masonry batteries have been condemned as worse than useless, as they would only make the ship's fire more destructive than if directed against guns *en barbette*.

Next comes the expensive alternative which has been adopted, viz: iron shields, casemates and turrets. It is most interesting to examine how far this system of iron, the last alternative left, meets the three requirements of coast defense alluded to, and to see what very great difficulties had to be encountered in applying it.

The three requirements are thus recapitulated:—1st. Strength of the battery to resist naval fire, and give sufficient protection to the men. 2d. Power of figthing the guns with accuracy and effect, of following the enemy with ease as he moves, of being able to face him on any side from which he approaches. 3d. Power of using the most formidable guns to advantage.

The first difficulty was to decide the matter of strength. Now guns are becoming more and more weighty and powerful every day, and therefore the strength required to resist them is an unknown quantity. An iron casemate of the present proposed strength costs, according to official returns, with all the battery adjuncts except the gun and carriage, about £5,000 or £6,000 for each gun. A 2-gun turret, about £25,000 or £30,000.* If guns of 50 tons are introduced in ships, as is proposed, these defenses are at once quite inefficient, and it is not known how strong or how expensive should be the iron works to replace them. Such questions must be very embarrassing indeed to those who have to decide these matters. Besides protecting the gun and carriage from the enemy's shot, protection must also be given to the men. This is the most serious of all considerations in coast defense, for the following reasons: The best experience we have regarding naval attacks on land-works is derived from the late American war, in which a great many actions of that kind took place. It would be unwise to ignore this experience, because the increasing power of artillery only gives it more weight. During the whole of that war very few guns were destroyed by the naval fire in earthen batteries. At Fort Wagner, only three guns were totally dismounted, although 2,864 shot and shell were fired into it in 48 hours, and the bomb-proofs were hit 1,200 times. Seventeen siege mortars, several cohorns and thirteen heavy pieces of artillery were incessantly employed. At Fort Fisher the bombardment was opened at the rate of 115 shells per minute, and although the guns were mounted *en barbette*, only two of them were dismounted when the place fell. At Fort Powell a tremendous bombardment from mortar and gunboats (the most accurate firing being from 15-in. mortars) was maintained from 22d of February till 2d of March, and not a single gun was dismounted. The success of the ships over the forts was gained by demolishing the works, and still oftener by making the service of the guns so dangerous that the men could not work them.

Rear-Admiral Porter, U. S. Navy, in his report on coast defense, states: "The new fashioned casemates turned out to be no better than the guns *en barbette*. They were perfect slaughter-houses, and were piled up with dead and wounded. Every shell that went through the port-holes killed and wounded every man in the close casemate. This proved to me most satisfactorily that guns in casemates were no better protected from shells than those *en barbette*."

With such evidence as this before them, from men who were conversant with all the events of that great war, it was indeed a serious question to decide what was to be done. I myself cannot see how men in an iron casemate are as much exposed as in a barbette battery; but there is no doubt that if the port of the strongest casemate was as large as those referred to by Admiral Porter, it would be open in the same circumstances to the same dangers, as the damage was done by entrance of shell through the port. The protection a casemate would afford from vertical fire in such a case would be but a poor advantage if more correct and more deadly weapons than the mediæval mortar could still search out at times the

*The price of a permanent Moncrieff battery, with magazines, etc., including the extra expense of carriages, is from £1,100 to £1,500 for each gun; an iron shield battery, from £1,800 to £2,000 per gun; an iron casemate battery, from £5,000 to £6,000 per gun; a turret, from £12,000 to £15,000 per gun.

exposed point of a casemate and kill every man inside. The next requirements in a coast battery, viz: to be able to follow an enemy amidst clouds of smoke, and to lay the guns on him with precision and dispatch, formed a more embarrassing difficulty still. On the one hand, the ports must be constructed for muzzle-pivoters to give protection. On the other hand, if they are made so small it is difficult to see through them, to fire correctly and quickly at different elevations and on different sides on a moving enemy. The battery is in the position of a knight, who must either expose his vitals to his enemy's lance or put on an armor that paralyzes his sword arm. There is as much protection in the power of being able to strike as there is in being able to guard. As naval actions are likely to be short and decisive, it must have appeared extremely doubtful whether it was worth purchasing increased safety at the expense of losing the attacking power. The last of the three requirements in coast defense stated was the necessity of using the most powerful canon. This did not present the same difficulty as the other two, because the designers of our defenses had been presented by my friend Captain Coles with the means of mounting the heaviest guns to fire in any required direction. When very large and valuable guns are used, it is not advisable to cramp their action and restrict it to a small area. The turret was therefore preferred to the casemate when lateral range was required; and though apparently very expensive, it was in reality cheaper than casemates, because, although the mounting of guns in this manner cost more, they were enabled to do much more work, and there was thus an economy both of guns and men.

Having thus far endeavored to describe the extraordinary difficulties which the new improvements in artillery inevitably entailed on the engineers, I shall now direct your attention for a short time to the difficulties in which the same improvements involved the artillerymen themselves. These difficulties, though not quite so important as the engineering ones, were very serious indeed, and had not yet been quite overcome. They consisted chiefly in the difficulty of making carriages and platforms strong enough for the new and powerful rifled guns. These pieces burnt enormous charges of powder, and hurled bolts as heavy as an old field piece at 1,000 ft. a second. The recoil of such guns represents a violence of force the like of which man has never had to deal with before. Imaging 12, 18, or 25 tons of compact iron started in an instant into rapid motion with a violence that mocks the blow of a steam-hammer. This force has to be controlled and restrained. It is no wonder then that, when met directly and stopped by friction, as is now done in the ordinary system, the difficulties are enormous. The horizontal strain on the platforms, pivots and racers, is so great that it has not yet been quite successfully met; constant changes and inventions are being made to render this force more harmless.

I hope I have now conveyed to your minds some idea of the embarrassment and difficulties which have fallen upon both the artillery and engineers by the rapid improvement of these formidable engines of war, and of the persistent, able struggle which both have maintained to meet directly the terrible forces with which they have to contend. They have both succeeded to a wonderful extent, but their success is blighted by that curse of the science they practice—the law that up to this time has existed—viz: that what was gained in protection was lost in efficiency, and the converse. Happily, I had the good fortune to conceive and develop an idea which abrogates this law. The very force, the existence of which has been so great a difficulty in the artilley question, has been compelled to perform a service that at once sweeps out of existence a great many of those other difficulties that embarrassed fortification. When two evils co-exist, it is sometimes good policy to make them destroy each other.

I shall now refer shortly to the train of ideas that led me to think of solving this important problem in quite a different manner from that in which it had been attempted, which had led to the adoption of a most expensive class of works. My solution gives a system capable of mounting the heaviest artillery, while it simplifies the vexed question of fortification. It gives protection without the expense of using iron, and free lateral range to the guns without exposure. The system is indeed a simple one; it does not require either brute strength or heavy expenditure for its application; nor does it need mighty forges to weld iron walls to protect our guns and gunners; it only calls to our aid the simplest and most docile forces of nature. Instead of trying to meet

force by force, I make my guns bow to the inevitable conditions which science has imposed; and instead of wasting energy, money and skill in attempts to raise a buttress against the new artillery, I employ the hitherto destructive force of recoil to lower the gun below the natural surface of the ground, where it can be loaded and worked in security and in comfort; and at the same time, I have made that destructive force so much my servant that I compel it at my pleasure to raise the gun again into the fighting position whenever it is required. In 1855, while watching the interesting operations before Sebastopol, and endeavoring, as well as I could, to understand the conditions under which the siege artillery was used, I conceived the idea which is now realized. It was then that I saw the value of earth and the importance of simple expedients. It was plain that the weak point of a battery was the embrasure, which formed a mark to fire at, an opening to admit the enemy's shot, and required constant repair even from the effects of its own gun, which in firing injured the revetments of the cheeks. I also came to the conclusion in my own mind that a remedy for some of these defects could be devised. Afterwards I worked at various plans, of which sketches were made, or models; but each design had defects which discovered themselves to me as my experience increased. The real difficulty of the thing arose from the necessity of providing for the enormous strain of the recoil. These early designs, which were sometimes excellent in other respects, broke down at this difficulty, and although some of them no doubt would answer with small guns, they were not calculated to meet the tremendous recoil of large rifled pieces.

At last I hit on a simple principle that would meet this difficulty to advantage—the interposition of a moving fulcrum between the gun and platform. Then I knew that the problem could be solved; and feeling the great importance of the subject, I resolved to devote my efforts to working it out completely. While directing my attention to this simple and then apparently obscure matter, I was, as you may imagine, neither an idle nor disinterested watcher of the progress of artillery. Every step in advance was riveting the certainty in my mind that the system would one day be required, and with this conviction I refused to allow either discouragement or delay to make me desist. I shall now endeavor to explain shortly the system which bears my name, as far as it relates to coast defense.

It consists of three parts: 1st. The mechanical principle of the gun carriages. 2d. The form internal and external of the batteries. 3d. The selection of ground for placing the batteries, and the arrangement for working them to the greatest effect; or, in other words, the *tactics* of defense for positions where the system is employed. The principle on which the carriage is constructed is the first and most important part of the new system, because on it depends the possibility of applying the other parts. This principle may be shortly stated as that of utilizing the force of the recoil in order to lower the whole gun below the level of the crest of the parapet, so that it can be loaded out of sight and out of exposure, while retaining enough of the force above referred to bring the gun up again into the firing or fighting position. This principle belongs to all the carriages; but the forms of these carriages, as well as the method in which this principle is applied, vary in each case. For instance, in siege-guns, where weight is an element of importance, the recoil is not met by counterpoise. With heavy garrison guns, on the other hand, which when once mounted remain permanent in their positions, there is no objection to weight. In that case, therefore, the force of gravity is used to stop the recoil, because it is a force always the same, easily managed and not likely to go wrong; and as these carriages are employed for the most powerful guns, it is a great advantage to have the most simple means of working them.

It has been already mentioned that the principal difficulty arose from the enormous and hitherto destructive force of the recoil of powerful guns; and here I shall point out the manner in which that difficulty is overcome. That part of the carriage which is called the elevator may be spoken of and treated as a lever; this lever has the gun-carriage axle at the end of the power-arm, and the center of gravity of the counter weight at the end of the weight-arm, there being between them a moving fulcrum. When the gun is in firing position, the fulcrum on which this lever rests is almost coincident with the center of gravity of the counter-weight, and when the gun is fired the elevators roll on the platform, and consequently the fulcrum, or point of support, travels away from the end of the weight-arm

towards the end of the power-arm; or in other words, it passes from the counter-weight towards the gun. Notice the important result of this arrangement. When the gun is fired its axle passes backwards on the upper or flat part of a cycloid. It is free to recoil, and no strain is put upon any part of the structure, because the counter-weight commences its motion at a very low velocity. As the recoil goes on, however, the case changes completely, for the moving fulcrum travels towards the gun, making the weight-arm longer and longer every inch it travels. Thus the resistance to the recoil, least at first, goes on in an increasing progression as the gun descends, and at the end of the recoil it is seized by a self-acting pawl or clutch. The recoil takes place without any jar, without any sudden strain, and its force is retained under the control of the detachment to bring up the gun to the firing position at any moment they may choose to release it. The recoil, moreover, however violent at first, does not put injurious horizontal strain on the platform. In my experiments at Edinburgh with a 32-pounder, I found that so slight was the vibration on the platform caused by firing that the common rails on which the elevators rolled in that experiment, and which were only secured in the slightest manner, did not move from their position, nor even when heavy charges or double shot were used, did sand and dust fall off their curved tops.

At a still earlier experiment made with a model of a 95-cwt. gun, the model was fired on the ice with excessive charges, and nevertheless remained stationary. This valuable concomitant of the system cannot be appreciated fully without referring to the difficulties that have been experienced, and are now felt, in getting pivots, platforms, etc., on the ordinary system, strong enough to mount the new artillery, where the recoil is stopped by friction applied directly by means of what are technically called *compressors* attached to the platform.

I shall not detain you by detailing these circumstances, but will only state that the first two 12-ton guns on ordinary carriages that were fired in casemates were both *hors de combat* the first shot. The accident referred to was serious, because it might occur in action, and in that event would disable the gun, *pro tempore*, as completely as if it had been dismounted by a shot. Some credit may be claimed for the new system, on the ground that it provided a carriage for a heavy piece of artillery on an entirely new principle, in which not a single part was copied from anything that had been formerly used, dealing with new conditions and performing the functions that no other carriage had done, and yet this new carriage (the first complete one of its kind) has now fired *two hundred rounds*. This practice has been carried on with only a few accidents which pointed to defects in the gearing, which were easily remedied. By treating this violent force in the manner above described, a good deal of the strength that is required in other systems becomes unnecessary. It will be observed that the interior slope of the parapet gives the most complete protection to the men, especially when the dome form is adopted.

Up to the present time the new system has only been considered as an improvement, and its value has only been estimated as an adaptation to existing forts, and there are no proposals for applying it *per se*. I am extremely anxious to impress on you and on my countrymen that its full value cannot be seen in this manner, and that it suffers injustice by being thus treated. I trust its proper use will be fully discovered before the inevitable lesson is dictated by war, and that it will be applied in works expressly designed for it, and not merely adapted to its use.

The third part of this system consists in its application to given positions and disposition of the batteries, and methods of working them in concert with and in support of each other. If I might be excused for using the paradox, this system of coast defense consists in the absence of any defined system; that is to say, instead of making large regular forts, and forcing surrounding circumstances into harmony with them, every accident of the ground in this case will be seized, where available, and small batteries, consisting of a few guns or of one powerful gun, laid down so as not to take away the natural aspect of the position. These batteries would be well retired from the channel, and placed so as to support each other in case of attack, and should, when circumstances permit, afford flank defense to each other, in conjunction with obstacles to the approach of the enemy. In connection with these gun carriages are some improvements of minor importance, such as trunnion pointers, reflecting sights, graduated races, and so on, which it would

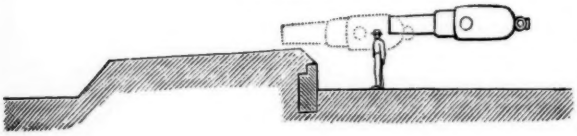
be out of place to discuss at present, but which contribute to the efficiency and completeness of the system, and are more or less required for carrying it out as a consisent whole for coast defense.

The second part of the system, viz: the profile of the batteries, is of the highest importance, because unless it is attended to great advantages are lost. This, unfortunately, makes the system extremly difficult of adaptation to existing works. In order to get the full advantage of it, no exterior slope of parapet should be exposed to the view of the enemy. This prevents him from being able to tell whether the fire be correct or wasted, and affords no means to him of correcting error. The battery, in fact, is masked; so that at some distance away, a moving ship would have considerable difficulty in laying her guns on one battery, and still more difficulty if there were several batteries judiciously placed for the purpose of deceiving the eye. It can easily be understood that the slighest error in elevation would either carry the shot harmlessly over the battery, or else cause it to ricochet off the glacis or superior slope. In fact, when the gun is down the enemy has nothing to aim at but an undefined horizontal line.

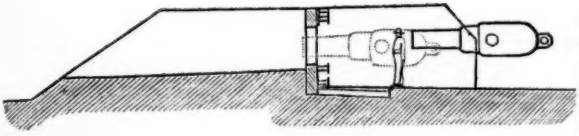
It is proposed to employ the Moncrieff batteries in connection with strongholds for infantry and light artillery, commanding, if possible, the sea batteries, so as to make them untenable by an enemy, and so placed as to be in the best position for a reserve, ready to support any point attacked; the whole connected with good and sheltered roads. In stopping the passage of a navigable river or channel, for instance, the guns, instead of being massed, would be scattered round the points where marine obstructions were placed. These guns would be disposed in such a manner as to retain as much as possible for the defense the advantages of a free lateral range, converging fire and different amounts of command. In other words, the method consists in placing in position the heaviest and most powerful artillery to the greatest advantage, making that the first consideration, and afterwards protecting the batteries, by separate and distinct arrangements easily devised by officers on the spot, against assault by any force that ships might land for that purpose When an object is to be obtained, I prefer to grapple with the most difficult and important part of it first, do that well, and meet the other requirements afterwards, with as little loss of efficiency as possible.

Sketch showing in section specimens of five methods of mounting heavy Coast Artillery.

BARBETTE.

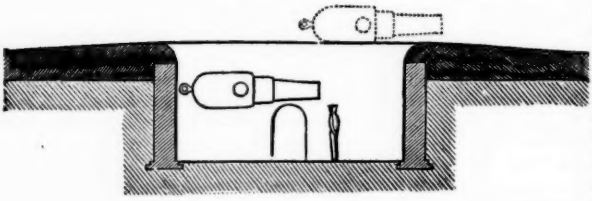


SHIELD.

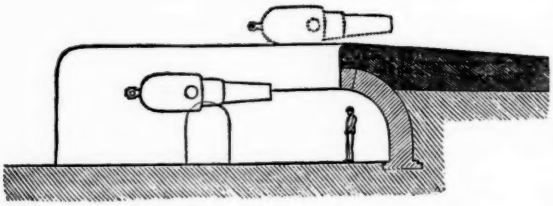


The first object of coast defense is to meet and defeat the attack of powerful ships; the next is to protect the shore batteries against landing parties. It must not, however, be forgotten that there are positions of such importance that they might be attacked by an army on land. Such positions must either be defended by another army placed in a favorable position by such arrangements as those above referred to, or else by regular and complete earthworks thrown up in time of danger, which would enable a still smaller garrison to resist anything but regular approaches. There are, however, few coast positions of such importance as to

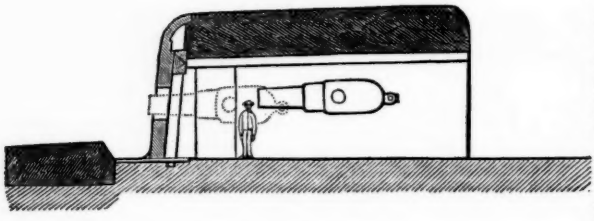
MONCRIEFF.



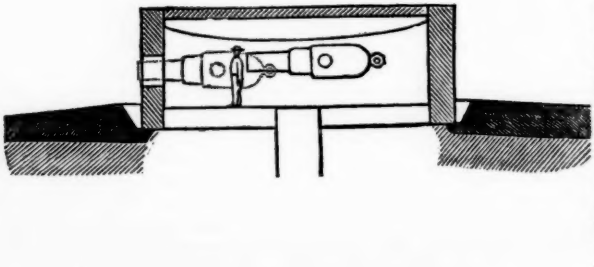
MONCRIEFF



IRON CASEMATE.



IRON TURRET.



draw the attack of a whole army; and such positions, as a rule, are now provided with regular works of a very high order; whereas there are many positions exposed to a naval attack, such as our large mercantile ports, etc.—They are almost invariably centers of population, which require only field-works and good small arms (which are now more powerful than ever) to repel the most determined attacks of any numbers that war ships could land. I believe many of the *present* coast works are defensible only against a *coup de main*. Wherever land attack is of more importance than naval, the character and efficiency of sea batteries must give precedence to those considerations which provide against assault. On the best provisions for meeting this I do not pretend to give an opinion. In such cases, the possibility of attack by both direct and vertical fire must be kept in view. Where my system is employed for arming such works, one or two precautions would increase the power of resistance. 1st. The large guns for operating against ships, with traverses and *parados* to each, should be kept as far apart as space will admit. 2d. Ample and thoroughly complete bomb-proof cover for the whole garrison should, if possible, be supplied in the middle of the work, with arrangement for interior defense(not barracks, but places for emergency) thoroughly secure from vertical fire—good and healthy barracks for the men being

made independent of the works, and by preference kept out of the way. 3d. Howitzers and light artillery ought to be kept in reserve, in bomb-proofs constructed for the purpose, and (with the new system this can easily be done) also with the means of changing these to any required face.

The dispositions of defensive batteries, such as those I have very imperfectly attempted to describe, would not be complete without good arrangements for internal communications, not only by roads, but by telegraph, with a clearly laid down and simple method of working them; that is, not liable easily to go wrong nor to lead to mistakes, and which would not require very high skill. Such arrangements would increase the power of the defense, and indeed would be necessary with the detached system. I have accordingly given them some attention, and designed a general plan of laying off the ranges and working the telegraphs, which will make it possible to supply simultaneous information. The system I refer to (which has been submitted to the Director-General of Ordnance) would apply to any position, but its particular application would vary in each case. It is extremely simple. One part of it depends on electrical instruments which I have invented for the purpose, and which, without either calculations or experience, give the range and positions of an indicated ship at every gun in the position.

Another part of it enables the officer directing the defense to deliver in one instant, by the touch of his finger, a converging volley from one or both sides of a channel on a vessel sailing past. The possibility of delivering correct fire in this manner on a moving object, without aiming, and by an officer not even in the battery, was illustrated in one of my experiments with the 7-ton gun carriage at Shoeburyness; and I trust I may be given some day a chance of showing to what perfection this system can be carried. Methods of determining the distance of vessels from batteries are practiced here and in some continental countries. My method is designed to be quicker, simpler, and therefore more effective. It is adapted to work in conjunction with the arrangements for sub-marine mines. That part of it which gives the required information for sighting the guns is of so simple a character that the most uneducated gunner cannot make a mistake in its application. There are many other features of the system besides those I have particularly referred to which I shall not now discuss; each requires different treatment. Among these there are methods of mounting guns in ships, floating batteries, Moncrieff carriages for heavy guns of position, adapted for locomotion, for coast defense and for siege carriages.

AMERICAN LOCOMOTIVE BOILERS.—It is impossible for an English engineer to read the records of American boiler explosions without being struck by the very large number of failures of locomotive boilers which occur annually on the other side of the Atlantic. In this respect the American records form a strong contrast to those of explosions in this country. Here the number of locomotive boiler explosions seldom exceeds three or four per annum, and considering the large number of locomotives now at work in the United Kingdom, locomotive boilers may be said to possess a greater immunity from explosion than almost any other class. To a great extent this is, no doubt, due to the fact that locomotive boilers are, almost always, worked under skilled superintendence, and subject to frequent inspection; but it is also due to their being, with but few exceptions, well constructed in the first instance, and properly proportioned for the work they have to perform. In America, locomotive boilers, although under quite as skilled superintendence as our own, are yet more liable to explosion from the fact of their having generally less superfluous strength when new than would be considered necessary by our railway engineers. American locomotive superintendents use $\frac{5}{16}$ in. and $\frac{3}{8}$ in. plates, where we should use $\frac{7}{16}$ in. or $\frac{1}{2}$ in.; and notwithstanding the high pressures used, double riveting is still the exception rather than the rule. The consequence of all this is that in a list, now before us, of 94 boiler explosions which occurred in the United States during 1868, no less than 23 explosions of locomotive boilers are recorded, these explosions thus amounting to over 25 per cent of the whole; while from another record of the explosions which took place in the month of May last, we find that during that month four locomotives exploded on different American lines. These are facts which demand the serious consideration of American locomotive engineers, and we trust that in the records of future years we may find evidence that the lessons which they teach have not been disregarded.—*Engineering.*

STATION ROOFS.—The large number of the members of the Institution of Civil Engineers will recollect the interest with which Mr. J. W. Barry's paper on "The City Terminus Extension of the Charing-cross Railway" was received at one of the meetings in the spring of last year. The paper and the discussion upon it has lately been issued to the members, and its re-appearance, in printed form, will revive, to some extent, the arguments advanced at the time referred to. A certain number of the speakers made common cause against roofs of large span, upon the sole ground of their cost, an objection equally applicable to the dome of St. Paul's, or the grand façade of the *Παρθενος*—the vestal temple of the goddess of Engineering, engineering being understood in its true Minervian sense of wisdom, war, and the liberal arts. Considered as a roof merely, a roof of great span costs more than a series of roofs of smaller span covering the same area. But, taking the roof as a part of a costly building, the difference of cost between a roof 200 or 300 ft. span, and two or three roofs of, respectively, one-half or one-third the span, is relatively small. The weight and cost of the principals alone rise in proportion of the square of the span, being, say, twice as much for a single span of 250 ft. as for two of 125 ft. The roofing or covering is of the same weight and cost, no matter what the span. In station roofs of from 212 ft. to 240 ft. span, the weight of the principals varies from one ton to one and a half tons only per running foot of the length of the building, so that in a roof even 800 ft. long, the saving by making two spans of 120 ft. instead of one of 240 ft. would not amount to more than the saving of from 400 to 600 tons in the principals, with the expense, on the other hand, of say, 150 tons of cast iron in forty intermediate supporting columns. The narrower spans are in any case the cheaper, but the utmost cheapness is not a *sine qua non* in buildings of a monumental character. Few genuine engineers, loving their profession for its own sake, would argue the contrary. Indeed, in the very discussion to which we refer, the arguments to the contrary came from a somewhat unfortunate contractor, and from the engineer of a non-dividend paying railway; an engineer who, having by his writings set up some pretensions to authority upon station construction and station architecture, has nevertheless given to the metropolis one of the ugliest works of its kind of which London has to be ashamed. Although, at present, works of associated private enterprise, railways are really as much public works as are the Government offices themselves, and, as public works, something beyond bare convenience is to be considered in railway-station architecture. The pretense that railway stations are unworthy of architectural treatment—a pretense often advanced—is in itself unworthy of our profession, unworthy of railway enterprise, and unworthy of public taste. And it is out of the question that a series of low, narrow-span sheds, such as might be run up for a manufactory or a warehouse, can be considered as an architectural work. In stations of which the total cost, apart from land and compensation, is from £150,000 to £230,000, and where architectural effect is almost incumbent upon the engineer, the difference of from £3,000 to £4,000 in the cost of the roof, representing an interest charge of from £150 to £200 per annum, is not a subject for very grave discussion. Where from five to ten million passengers pass through such a station yearly, the cost to each passenger, at each journey, is but from, say, the $\frac{1}{150}$th to the $\frac{1}{200}$th part of a penny, or a penny for every 150 to 200 journeys, short or long, say a penny every three months for the season ticket holder entering and leaving the station daily six times a week. A daily traffic of from 20,000 to 40,000 passengers, half in each direction, is nothing very remarkable "in and out" of a great Metropolitan station. The cheese-paring engineers, of whom there are a good number, may, possibly, in view of such easily established facts, condescend to admit that considerations of grandeur and general effect, attended also with greater convenience, comfort and safety, should be allowed to have some weight in station design.—*Engineering.*

TURBINE TESTS.—Frequent inquiries are made for full and trustworthy data regarding the economy of turbine wheels, especially the new wheels so vigorously advocated of late. Some of these have merit we believe, but the public require better proof than interested statements. A commission of engineers, whose ability and character are above suspicion, should be asked to undertake tests at the joint expense of the wheel makers. Such a trial would be exhaustive and convincing, and moreover it would greatly stimulate the turbine wheel trade.

SEWAGE CARRIED BY WATER.

From "The Artizan."

The transporting power of water, when conveying sewage, is becoming a subject of very great importance, as both the fertility of the soil and the sanitary state of our large cities are affected by it. It is now pretty generally admitted, that plants can best absorb nourishment from the soil when the soil receives the manure in a liquid form; but it also would appear that vegetables do not thrive so well when the water is very highly loaded with sewage.

There would, therefore, seem to be some certain proportion of water and sewage best adapted for the soil to absorb and again to give it off to the plants; and possibly this very proportion is also the best when water is the medium by which the sewage is transported, while at the same time it may be found that a city requires just this quantity of water to insure proper sanitary measures being carried out.

It is self-evident that the refuse of our cities could not be made to flow without water—be the slope or head of pressure ever so great; and also that pure water will flow with almost an imperceptible slope, but under such circumstances this pure water could not hold in suspension any foreign matter. Again, as it is necessary that sewage should be conveyed under ground for sanitary reasons, and that to utilize this sewage for irrigation it will require, under most circumstances, to be again pumped up, the question is, what is the velocity, in other words, the slope or head of pressure that should be given, which will require the least power to be expended in pumping?

If too little water be used, we must increase the fall, while too much of it involves needless pumping. It is, therefore, quite possible that it may be discovered that the proper liquification of sewage, so as to have the least expenditure in pumping, may be also the very same proportion per head required by our cities for sanitary purposes, as well as the very best proportion for agriculture.

The question, though very complicated, is one of great interest; and its importance is becoming more and more evident. That the soil can, when irrigated by sewage water, absorb the foreign matter, and give it out again in the best possible state for the growth of plants, is admitted, while the water being relieved of this matter, sinks into the ground below in almost a pure state; so this very water, which has been taken from a river high up in its course, can be made to supply our cities; then convey away the refuse, distribute it over the fields, adding to their fertility, and again return to the parent stream through the underground springs in a state to aid rather than injure navigation, for it brings no foreign matter along with it.

According to Beardmore, a bottom velocity of 40 ft. a minute will sweep along coarse sand, and 60 ft. fine gravel, but this is with pure water not already loaded with solid matter. What may be the necessary velocities with various loads of solid matter held in suspension, are questions yet to be determined by experiment. So as water holding sewage matter in suspension must be affected by the load it has to carry, the velocity requisite for sweeping along coarse sand under such circumstances, must be much greater than if only pure water was the disturbing medium.

For the sake of argument, suppose that a mean velocity of 1 ft. per second is the necessary velocity in a closed pipe, the question is, what is the size of pipe required to convey away the sewage of a given number of inhabitants?

Let this number be 100, and that two cubic feet of water (rather over 12 gallons) is the water supply for each man, woman, and child, during the 24 hours.

Now, as eight out of the 24 hours is required for sleep, there remains only 16 hours of the day that the greater portion of the sewage is supplied, and during certain hours of the day there must be a greater discharge than at others; allow one-fourth more to be deducted to admit of the maximum discharge, or in all only 12 hours.

The rate of discharge per second would therefore be

$$\frac{100 \times 2}{12 \times 60 \times 60} = .048 \text{ cubic feet,}$$

or 82.944 cubic inches, which it is supposed requires a mean velocity of a foot a second, that is 12 inches; so $\frac{82.944}{12} = 6.912$ sqr. inches is the sectional area required for a pipe to discharge the sewage for 100 inhabitants; or a three-inch pipe is sufficient to pass off this maximum discharge of sewage of 100 men, women, and children.

Again, suppose that the ground is such that there is *no available fall* along the line

this sewage has to be discharged, and the length of pipe is 500 yards, the question is how to obtain the velocity of one foot a second?

Adhering to Beardmore's tables, the discharge being .048 feet a second, or 2.880 ft. a minute, distance 1,500 ft., and diameter of pipe 3 in., there is

$$\frac{1,500}{\left(\frac{73.6}{3}\right)^2} = 2\tfrac{1}{2}$$

That is, with $2\frac{1}{2}$ ft. head of water and a three-inch pipe (which is 500 yards long), in 12 hours this pipe could discharge the sewage of 100 inhabitants, but if the head of water was raised to 10 ft., this same pipe could discharge more than four times as much.

The question is, how is this fall to be obtained on perfectly level ground? and the answer is, by pumping; but it is obvious that *all* the water does not require to be pumped, but only a small portion of it, by simply having all the water-closets in a house above the level of 10 ft.; and whatever water may be used in the kitchen or ground floor only, can be pumped up to the required level, a work that would hardly occupy the kitchen servants above a quarter of an hour daily. There will also be this advantage, that, having to pump up all the dirty water in the sink or cesspool, no bulky matter could find its way *up* the pump, but would have to be removed by hand to the ash-pit, to be carted away in a dry state; thus there could be no danger of the sewage pipes ever being blocked up by solid matter.

Mr. Chadwick, in his report on the Paris Exhibition on dwellings for the working classes, has drawn attention to a number of most important sanitary questions, of which the above is one of them, and at page 76 of this able report points out, that fresh sewage that has not undergone the process of decomposition is not only more valuable in its fructifying power in the proportion of one to three; but, instead of killing fish when it escapes fresh into a river, the fish come and feed on it. So the question is, why is it that there has been so great an outcry about the evil effects of the sewage of our cities?

The reply is, that it is from a want of a proper knowledge of the abrading and transporting power of water, and to prove this, one example will be sufficient. At a well-known watering-place on the west coast of England, the local board of health are at present constructing a culvert to convey away the drainage and sewage of a portion of the town. The land is nearly level, so there is no great outfall that the sewage and drainage can flow off quickly by its own gravity. To provide, therefore, for this want of natural fall, the channel along which the sewage and drainage is to escape is made large, the culverts being 2 ft. by $1\frac{1}{2}$ ft., of egg-shaped section. The houses for which this sewer is being built are twelve in number, containing something rather under 100 inhabitants, and this drain is 500 yards in length, which will cost somewhere about one pound sterling per running yard, which, at five per cent, is an annual tax of rather over £2 a house.

Now the first mistake made in this town, we are of opinion, is combining the storm with the sewage drainage; for the former could, with impunity, be permitted to drain into the sea; but this mistake probably arises from a want of a proper knowledge of the abrading and transporting power of water, for if the storm drainage has already got its proper load of solid matter, where probably the slopes over the surface are much greater than within the culverts, it is evident that the highly charged storm water cannot aid in scouring out any prior deposit, but will rather add to it. Consequently, the admission of this storm drainage rather tends to block up the culvert sewers instead of keeping them clear, so there can be nothing gained by having large sewers to convey away the storm drainage also.

It has been said that the sewer now being built has a section of 2 ft. by $1\frac{1}{2}$ ft., but taking the nearest size to this, 2 ft. by $1\frac{1}{4}$ ft., given in Beardmore's tables, where there is a fall of 2 ft. in the mile, with a depth of 12 in. of water in the culvert, we only get a velocity of 59.9 ft. a minute, or what we started with, as required to move along sand by sewage water; but we also find that to give this depth of water, the discharge requires to be no less than 52 ft. a minute, or eighteen times more than the sewage of one hundred inhabitants, while with any decreased velocity it is supposed sand cannot be transported. The natural consequence is, therefore, that the sewer must get filled up, till it has reduced the opening to such an area that the velocity acquired by having to pass through such a small opening, can enable the water to sweep along sand, or, in other words, the culvert sewer

gets filled up with decomposed putrid sewage, that poisons the air, earth, and water, while for some one-tenth of the cost probably, a proper system of sewage pipes could be laid down, so that even a new set of pipes could be laid down every other year at no greater cost than the interest on capital laid out on the culvert sewer.

By this head of pressure system also, it is evident that for irrigation purposes there would be little trouble in spreading the sewage over the lands, while by the increased velocity the land would receive it in a fresh state, and thus the greatest benefits to the soil would be secured without any deteriorating effect on the health of the inhabitants, and all at what cost? Merely that the kitchen servants, for a quarter of an hour or so daily, would have to pump up the water in the cesspool to a higher level of some ten feet or so above the sewage-pipe outfall, and thus all these ingenious methods of separating all sorts of rubbish would not be necessary, for they could not be pumped up from the sink, so that only paper in a state of pulp could pass down the pipes. The servants might at first object, but not where sewage arrangements are introduced for the first time, and once the advantage of this system were proved, all objections would soon disappear.

THE ALLOYS OF ALUMINUM WITH COPPER.

From the "American Horological Journal."

When Sir Humphrey Davy announced the fact that soda, lime, potash, magnesia, and the other alkalies were but oxides of a metallic base, it would have been deemed chimerical to have supposed that the discoveries he made by the expensive aid of the battery would at later date become of really commercial value. He did obtain both sodium and potassium in the metallic state. The substances in this form were new to the chemical world, still more strange to the popular. So new was it to the chemists that, on a globule of the reduced sodium being presented to a very distinguished chemist, he, with some enthusiasm, examined it; and, admitting the fact of its being a metal, exclaimed, "how heavy it is!"—when the real fact was that its specific gravity was less than water; the expression was the result of the general pre-conceived opinion that a high specific gravity was a test of a metallic body. It was reserved for a French chemist, Henry St. Claire Deville, to utilize the metal sodium, and that, too, in such a manner that the demand aroused attention to its production;—demand will inevitably bring a supply.

The original reduction was made by Davy by means of the voltaic battery. After it had been proved that these bases were really metals capable of reduction, chemistry brought all its resources to bear on the problem, and they were produced by other methods than the battery. All the processes adopted, however, were too expensive and laborious, involving an extraordinary amount of complicated manipulations with but inadequate results. The metal sodium, which is the immediate subject of our inquiry, long remained an object simply of curiosity or experiment in the laboratory.

The methods of reducing the metal have of late years been so simplified that, to quote Prof. Chas. A. Joy, in the "Journal of Applied Chemistry": "A few years ago a pound of this metal could not have been purchased for two hundred dollars, and even at that price there were few manufacturers hardy enough to take the order. At the present time it can be readily manufactured for seventy-five cents, if not for fifty cents a pound; and the probabilities are that we shall soon be able to obtain it for one-quarter of a dollar."

Deville found that by the reaction of the metallic sodium on common chloride of aluminum, a reduction was effected; the chlorine taking up the sodium, forming chloride of sodium (common salt), while the aluminum was left free in the metallic state. It is hardly necessary to go into the particulars of the process; but a metal well known to exist, had, for the first time, been brought to the world in such a condition of structure that its qualities could be tested, not only chemically, but mechanically. This was the direct result of Deville's metallurgic process of obtaining the reducing agent—sodium.

Aluminum in itself would be of but little use, so that a brief description will be all that is necessary. It is about the color of silver, but susceptible of a higher polish, especially on a fresh-cut surface; it is much less susceptible of oxidation than silver; its specific gravity is but little more than pine wood, and its tenacity, ductility, and laminating qualities are nearly equal to silver. Its use in the mechanical arts is limited,

notwithstanding all these qualities, from the fact of its low point of fusibility, and at the heat of the fusible point being easily oxidized, so much so as to prevent soldering, except by an antogenous process. But aluminum does possess a property peculiar to itself—that of forming a purely and strictly *chemical alloy* with copper. It unites with it in any proportion; the compound formed by the addition of 10 per cent of aluminum to 90 per cent of copper has been found to possess all the properties of an entirely new metal, with qualities that render it a very valuable material in all fine work, such as astronomical instruments; and very fine machinery, such as watch-lathes, etc.

The French reports on the alloy are somewhat voluminous, but we give the following:

The color of this bronze so closely resembles that of 18 carat gold, such as is used for the best jewelry and watch-cases, that it is capable of receiving the highest polish, and is far superior in beauty to any gilding.

Samples taken from different parts of the largest castings, when analyzed, show the most complete uniformity of composition, provided only that the two metals have originally been properly mixed while in a state of fusion. These experiments have been made upon cylinders weighing many hundreds of pounds, and are entirely conclusive.

This valuable quality is not found in any of the more ordinary alloys of copper. The alloy of copper with tin, for example, known as *gun-metal*, is notoriously subject to a phenomenon known as *liquation;* in consequence of which a great difference is found in the composition of the same casting, both in the top as compared with the bottom, and in the center as compared with the circumference.

This phenomenon often causes great inconvenience, as the different parts of large objects will, in consequence, vary greatly in hardness as well as in strength. In casting artillery the difficulty becomes a serious one, and no means have yet been discovered by which it can be entirely removed.

This homogeneousness of aluminum bronze is a natural consequence of the great affinity existing between the two metals of which it is composed; and that there is such an affinity is clearly proved by the phenomenon attending the manufacture of the alloy. The copper is first melted in a crucible, and the aluminum is then added to it *in ingots*. At first there is, of course, a reduction of temperature, because the aluminum in melting absorbs the heat from the melted copper; and this absorption is so great, in consequence of the great capacity for heat of aluminum, that a part of the copper may even become solid. But let the mixture be stirred a moment with an iron bar, and the two metals immediately unite; and in an instant, although the crucible may have been removed from the furnace, the temperature of the metals rises to incandescence, while the mass becomes as fluid as water.

This enormous disengagement of heat, not seen in the preparation of any other ordinary alloy, indicates, not a simple mixture, but a real chemical combination of the two metals. The ten per cent bronze may therefore be properly compared to a salt, the more so as it is found by calculation to contain, within a very minute fraction, four equivalents of copper to one equivalent of aluminum.

The ten per cent bronze may be forged cold, and becomes extremely dense under the action of the hammer. The blades of dessert-knives are thus treated in order to give them the requisite hardness and elasticity. But it has another valuable quality which is found in no other kind of brass or bronze. It may be forged hot as well as, if not better than the very best iron. It thus becomes harder and more rigid, and its fracture shows a grain similar to that of cast steel. On account of the hardness of the aluminum bronze, rolling it into sheets would be a tedious and expensive process, were it not for this property of being malleable at a red heat. But it may in this manner be rolled into sheets of any thickness, or drawn into wire of any size. It may also be drawn into tubes of any dimension.

From several experiments, made at different times at Paris, it appears that the breaking weight of the cast bronze varies from 65 to 70 kilogrammes the square millimeter. The same bronze drawn into wire supported a weight of 90 kilogrammes the square millimeter. The iron used for suspension bridges, tested in the same manner, did not show an average of more than 30 kilogrammes. Some experiments were also made by Mr. Anderson, at the Royal Arsenal at Woolwich, in England, who tested at the same time the aluminum bronze, the brass used for artillery, and commonly called *gun-metal*, and the cast steel made by Krupp in Prussia. Taking for the maximum strength of the bronze the lowest of the numbers

found, as above, we are thus enabled to form the following table of comparative tenacities :

Aluminum bronze, 10 per cent.....	65
Krupp's cast steel.....	53
Refined iron.....	30
Brass for cannon	28

The comparative toughness of these same four metals was also tested in the following manner: A bar of each was prepared of the same size, and each bar was then notched with a chisel to precisely the same depth. The bars were broken separately, upon an anvil, by blows from a hammer. The last three metals in the table broke each at the first blow, with a clean and square fracture. The aluminum bronze only began to crack at the eighth blow, and required a number of additional blows before the two pieces were entirely separated. And the irregular, torn surface of the fracture showed the peculiarly tough and fibrous nature of the metal.

The elasticity of the aluminum bronze was tested by M. Tresca, Professor at the *Conservatoire des Arts et Métiers*. The experiment was made upon a bar of simple cast metal, and the following is his report: "The co-efficient of elasticity of the aluminum bronze, the cast metal, is half that of the best wrought-iron. This co-efficient is double that of brass and four times that of gun-metal, under the same conditions."

The specific gravity is 7.7, about the same as iron. Another very valuable quality is presented in the fact that it is acted on by atmospheric influences less than are silver, brass or bronze. This places it in the same rank with gold, platinum and aluminum.

Very stiff and very elastic, tougher than iron, very little acted upon chemically, and in certain cases not at all, capable of being cast like ordinary bronze or brass, forged like iron and steel, of being worked in every way like the most malleable metals or alloys, having added to these properties a color analogous to that of the most precious metal, this bronze proves itself adapted to uses almost innumerable. At first sight, it seems difficult to admit that the relatively small proportions of aluminum which enters into the composition of this bronze can be sufficient to modify so extraordinarily the properties of the copper which constitutes so large a portion of its weight. But we must remember that the specific gravity of aluminum is very low, and that a given weight of this metal possesses a bulk four times as large as the same weight in silver. It follows from this that the ten per cent of aluminum contained in the bronze equals in bulk forty per cent in silver.

The specimens of the ware we have seen, such as spoons, forks, cups, watch-cases, etc., are certainly very beautiful, having the color and high polish of gold, while dilute acids do not affect the surface.

SUBMARINE RAILWAYS.

From "Engineering."

It is sixty years since Trevithick, undeterred by the unsuccessful attempt of Ralph Dodd, began a tunnel under the Thames, working from the Rotherhithe shore. He carried it upwards of 1,000 ft. under the river, and to within 100 ft. or so from the Middlesex bank, when the result of a rash experiment, undertaken by himself, was to flood the works with water. The history of the present Thames Tunnel, now about to become a railway tunnel, is sufficiently well known, and it is also well known that the Botallick mine, in Cornwall, extends for some distance beneath the Atlantic, and it is said that the miners can hear the roar of the waves, or, at least, the crashing roll of the shingle over their heads during storms. Our own columns have contained full accounts of the most important example of tunneling beneath water, viz: the Chicago Lake Tunnel, extending for two miles beneath Lake Michigan, and to a point over which the water is 40 ft. deep, the tunnel itself being 70 ft. beneath the surface of the lake. This work was carried through a bed of impervious clay, previously bored at a number of points sufficient to establish its perfect continuity, and the tunnel was lined with brick work as fast as the headings themselves were advanced. Here the work was, from the first, as reasonably certain of success as its subsequent progress was easy and straight-forward.

The grandest example of subaqueous tunneling, should it ever be carried out, will be the submarine railway from the South Foreland to the French coast, near Calais. The under sea portion will be 22 miles in length (of course without shafts), under water of a maximum depth of nearly 200 ft. at high tides, and at a distance or depth of from 250 ft. to 320 ft. beneath the bottom of the Channel. A question of great present interest is, Can this tunnel be made? It is well nigh settled. beyond geological dispute,

that there is no continuous bed of clay through which it can be carried, unless through a comparatively thin bed of gault of uncertain dip and direction—a bed which, from such examination as it has been possible to make, appears to crop out across the bottom of the Channel between Abbot's Cliff and Cape Blanc-nez. The designers of the Channel Tunnel have preferred, therefore, the lower or gray chalk, and have proposed a line two or three miles only to the north-east of the out-crop just named, with its superior out-crop of green sand. The dip, to the north-eastward of all the strata, is quietly estimated at 100 ft. per mile, although there is not an authenticated axial (longitudinal) section of the Channel in existence, to show what is the real declension, to the north-eastward, of the strata of its bed. The proposed tunnel would pass under the deepest part of the Channel, between Dungeness and the North Foreland, while it would not permit of the shortest crossing, possibly and probably the shortest crossing is not practicable for a submarine tunnel. One enterprising projector would carry a tunnel through the green sand, but those who would carry it through the chalk would still be sailing very close to the wind, with the certainty that if a "fault" or fissure were met with, an irresistible stream of water, under from 200 lbs. to 225 lbs. pressure per square inch, would quickly dispose of all the work previously done. There are large, unmistakable and well recorded faults in the chalk beneath London, and, what with seismotive action—and we *do* hear of earthquakes even in England—there may be larger faults beneath the Channel. That men can be found, by hundreds, to work the headings of a Channel tunnel, need raise no doubt whatever. But that these men would ever come out of the headings, dead or alive, is another matter. If the headings once fail, all hope is well nigh lost. It is proposed, by the engineers to the International Commission, to make two headings from each coast, each 9 ft. square. Two headings are proposed, upon an assigned theory of ventilation, but it is clear that a single heading can be perfectly ventilated by compressed air, while it is certain that two parallel headings would but double the risk without economizing time. With a single heading, 9 ft. square, once safely carried through, there would be no great difficulty in enlarging it to a tunnel 28 ft. or 30 ft. wide. But the roof of this heading, occupying, perhaps, five years in making it, would present a surface for percolation of 24 or 25 acres, and it could not be bricked up as the work proceeded. One, two, or three years after a portion of the heading had been completed, a resistless torrent of water might suddenly come through, destroying not only the whole work, but all within it. To undertake such a work, even if it be not tempting Providence, is, at least, to incur tremendous uncertainties, considering that it would be through a comparatively unexamined bed of chalk, but two or three miles from the out-crop of half a dozen strata.

But supposing the heading, or a parallel pair of headings once made, and the tunnel afterwards made, as it could then easily be made, there would not only be nearly 30 miles of continuous tunnel for the passenger, but this would be upon a line involving a long and circuitous route to Paris. If Paris be the "objective point," it would at least be 25 miles further from London *via* Dover, by Mr. Hawkshaw's, than by Mr. Fowler's route, the latter a steamboat route. From London to Dover is 78 miles by the Chatham and Dover, and 76¾ miles (*via* Sevenoaks) by the South-Eastern. To Folkestone the distance is 71 miles only. Yet the proposed tunnel is to be carried well to the east of Dover, say to the South Foreland, and instead of being directed well into the course of the Belgian and North German traffic, it draws short of Calais, and connects more directly with the line between Calais and Boulogne, making it well nigh the most roundabout route between London and Paris.

The Channel Tunnel, estimated at £10,000,000, involving an interest charge, at 4 per cent, of more than £1,275 per day, of 313 working days per year, would admit of any traffic, however extensive, would conduct it at the average working rate of 35 or 40 miles per hour, without detention by tides, fogs, storms or the chances of collisions. It is doubtful whether it can be made, equally doubtful whether it could ever "pay," except in the far distant future, with trains every quarter of an hour. That all trains would require to be lowered 500 ft. or 520 ft. at each end, and again pulled up through the same distance, is by no means an insuperable objection to the tunnel. Nor do we apprehend any insuperable difficulties in the way of draining or ventilating. Both, for anything we can see, may be easily, successfully and permanently managed.

On the other hand, an absolutely certain

means of communication, for which nature has provided the "permanent way," if that term may be applied to a tidal sea, is already to be found between Folkestone and Cape Gris-nez, Audrecelles, Ambleteuse or Boulogne. The shorter the sea passage desired, the nearer must the route bear towards Cape Gris-nez. Indeed, Dover pier and Cape Gris-nez are separated by the least distance of any points between England and the Continent, say 17½ knots. But Cape Gris-nez would not make a good landing place for steamers, and so for the Belgian and German traffic, the route would require to be drawn more towards Calais, and so for Paris, it would require to be drawn more towards Boulogne. Of all the existing routes, they are diagonal between two nearly parallel coasts; in fact, there is no *direct* route across.

The railway ferry boats proposed by Messrs. Fowler and Wilson, would cross between Dover and Audrecelles, the latter about 7 miles north of Boulogne. By leaving Folkestone instead of Dover, they would save from 5½ to 7 miles of land journeying on the English side, and by making the French port a short distance south of Cape Gris-nez, about two miles north of Audrecelles, they would reduce the sea journey to less than that now attending the Dover and Calais route. To the point named (or rather not named, as bearing no name) the steam service between England and France would be well nigh the shortest practicable. Four or five miles of railway on the French side would connect it with the existing Calais and Boulogne railway, one of the crookedest and worst in France, except between the proposed point of junction and Boulogne. It would be objected that this route would take vessels across the "Varne" and the "Ridge," or "Le Colbert," the most dreaded sand banks, next to the Goodwins, of all in the Channel. But by planting a sufficiently visible beacon on the head of the Varne, a course might be taken to the northeast of it, which would, at low water spring tides, carry over a vessel drawing 24 ft. with more than 40 ft. of water over the northeastern end or head of the "Ridge."

The tunnel, estimated to cost £10,000,000, and attended with an interest burden of £1,275 per day, might, for twenty trains each way daily, be worked at a cost of less than £200 per day. To perform the same service, probably ten boats, costing each £100,000, would be required, and it is not perhaps far out of the way to allow £1,000,000 for the improvements of the ports of Folkestone and the inchoate port south of Cape Gris-nez, but a little north of Audrecelles. Upon these would rest the interest at 5 per cent, of £100,000 per annum, together with a further sum of £100,000 per annum for depreciation on boats. Beyond these sums would be the cost of repairs of boats, say £50,000, besides coal, wages, &c., bringing the whole, probably, up to nearly or quite £300,000. The boats would not prevent sea-sickness, and they would be more or less exposed to the risks of collision. They might run aground, especially in shallow harbors, and at low tide, and however fast they might be as boats, they would be slow as compared with railway trains, the more so as they would require a considerable interval of time in receiving and discharging their deck load of passenger and goods carriages. Still, this brief examination by no means exhausts the subject.

THE BESSEMER MANUFACTURE IN THE UNITED STATES.—The Pennsylvania Steel Works at Harrisburg are regularly making eight five-ton heats every day of twelve hours. This would be equivalent to sixteen heats, or 65 or 70 tons of ingots per twenty-four hours. Eight heats in twenty-four hours is considered fast work in England. It is now over eighteen months since a heat has been lost at these works through the failure of the machinery or refractory materials—a result more remarkable even than the large product. The new five-ton plant of Messrs. John A. Griswold & Co., at Troy, is nearly completed, and will have a greater capacity than any other in this country. The two-ton converter at these works is regularly making ten heats per 24 hours, which is good work for a single vessel. An 18-inch merchant mill, made very heavy and specially adapted to steel, has also been started by this company, and is now turning out bars up to four inches round or square.

Mr. John C. Thompson has resumed the superintendence of the Cleveland works. The Lewistown works are executing a large rail order for the Pennsylvania railroad. The Steel Works of the Cambria Iron Company, at Johnstown, are approaching completion, and will be, in many respects, the finest Bessemer works in this country.

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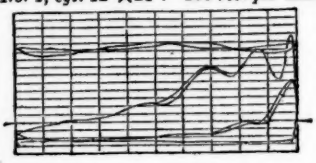

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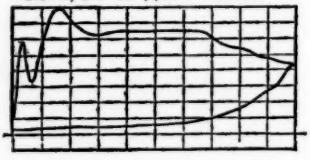

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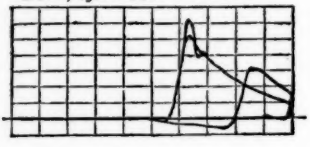

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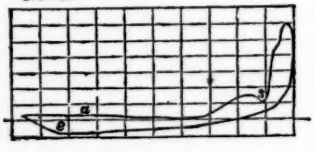

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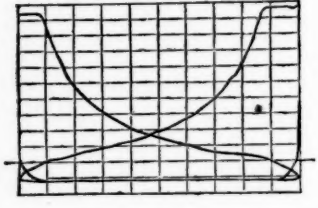
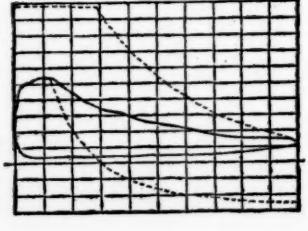
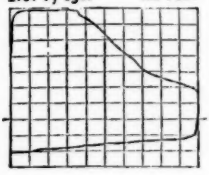


No. 6, *cyl.* 19¾″×21⅝″. 80 *rev.*



No. 7, *cyl.* 25 *rev.*



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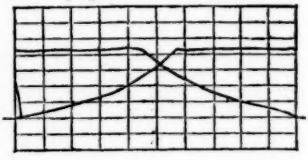
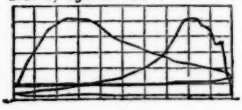
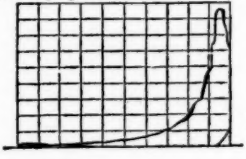


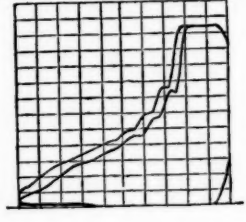
No. 9, *cyl.* 16″×30″. 68 *rev.*



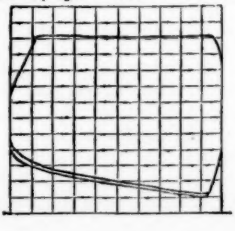
No. 10, *cyl.* 16″×30″. 68 *rev.*



No. 11, *cyl.* 16″×30″. 68 *rev.*



No. 12, *cyl.* 16″×30″. 68 *rev.*



INDICATOR CARDS.

FROM STANDARD AND EXPERIMENTAL ENGINES.

Compiled from the proceedings of the Association of Engineers and Architects.

A suitable description of the Indicator, by which the diagrams referred to in this paper were taken, may be found in C. T. Porter's "Richard's Indicator," published by D. Van Nostrand, of New York.

Diagram No. 1 is from an "Allen" Condensing Engine at the Paris Exposition of 1867. The waving of the expansion line is caused by the excessive momentum of the Indicator piston, due to the high speed of the engine, which cannot be taken up by the spring quickly enough to give the usual regular outline to the diagram. The irregular, nearly horizontal line at the top of the diagram was drawn when the indicator was attached to the steam chest, and shows the pressure of steam as slightly lessened when at the beginning of the stroke a large quantity passes into the cylinder. The atmospheric line is shown in each diagram extending beyond the ends of the rectangle. The spaces between the horizontal lines on No. 1 represent 4 lbs. pressure.

No. 2 is from a Reed and Cogswell oscillating engine. The slow and tardy opening of the steam and exhaust ports is clearly shown. In this 4 lbs. to each space.

No. 3 from a Lenoir Gas Engine. The gas and air pass into the cylinder through valves which close at about half stroke, and the mixture is then ignited by an electric spark, or by other suitable means. 8 lbs. to each space.

No. 4 from a non-condensing engine in a rolling mill at Trenton, and shows the result of an accidental displacement of the pin from which the paper received its motion. The engine has a heavy fly-wheel, and at the time when this diagram was taken, was running without load. The point of admission is at *s*; the opening of the exhaust is at *e*; the back pressure against which the return stroke is performed is shown by the line at *a*; and the rise of the line from *a*, toward *s*, is due to the compression occurring in the cylinder before the beginning of the next stroke.

No. 5 from the U. S. gun-boat "Algonquin," with a Sickles cut-off. 4 lbs. to each space.

No. 6 from an engine having a poppet-valve cut-off, tripped by the action of the governor. 4 lbs. to each space.

No. 7 from the steam cylinder of a condensing blowing engine at Harrisburg, Penn. 6 lbs. to each space.

No. 8 from the air cylinder of the same engine, having valves made of a rubber band, opened and closed by the pressure of the air. 6 lbs. to each space.

Nos. 9, 10, 11, and 12, are all from a non-condensing Corliss engine, at Trenton, New Jersey. No. 9 shows the distribution of the steam by the valves as they had been set for many months previous to the application of the Indicator; and Nos. 10, 11, and 12 give the improvement shown by its use to be needed and entirely practicable. It was effected by merely moving the eccentric ahead upon the shaft so that the valves were all opened earlier. In all these, 6 lbs. to each space.

No. 12 shows a high back pressure with the engine following full stroke. No. 11, the distribution of steam when cut of at $\frac{1}{4}$ stroke, and No. 10, when no work was done except driving a fly-wheel and gearing, by which the power was transmitted to the train of rolls.

LEAD AS A COVERING FOR ROOFS.

By Mons. C. DÉTAIN, C. E., in "Revue Générale de l'Architecture."

Properties of Lead.—Lead is of a bluish-gray color, usually dimmed after being submitted to the action of the air, but lustrous when recently cut or scraped. It remains unchanged for some time in a dry atmosphere, but if subjected to the action of humid air it soon becomes covered with a blackish pellicle. This coating preserves the rest of the metal from oxidation, in the same way that a covering of the same nature preserves, with even greater efficacy, zinc surfaces. "Pure lead is not affected by perfectly pure water free from air, but if air be present the metal is oxidized at its expense, and the oxide thus formed, combining with carbonic acid, is deposited on the lead in minute crystals as a basic carbonate of lead. The water will then be found to contain lead in solution, and such waters drawn from impure cisterns, often produce very distressing consequences. If the water contains any sulphates, the lead is thrown down as a sulphate of lead, which is insoluble." ("Ure's Dictionary," 6th edition.)

In a state of purity lead is very soft—it

may be scratched with a finger nail, and readily cut with a knife; rubbed upon paper it makes a metallic gray stain. Its malleability is very great, so great that it may be beaten into thin leaves and drawn into very fine wire, but it has but little tenacity—only about one-fourth that of zinc. A wire of one-twelfth of an inch diameter will not support 20 lbs. Lead which has been prepared by the old method, that is to say, by casting, much in the same way that plate glass is manufactured, has about the same tension as rolled or milled lead, but the cast lead breaks abruptly, presenting a clean, granulous fracture, whilst rolled lead, before giving way, is drawn into threads, so to speak. The rolling process has a great influence upon the ductility of this metal. The result of numerous experiments is that relatively laminated lead is to cast lead as 7 is to 5. The ductility of the latter kind appears to be the same for all thicknesses, whilst that of laminated lead appears to increase with the hammering to which it is subjected. Cast lead is firmer and drier, as the workmen say, than rolled lead. Its surface is marked by an infinite number of minute pores, which give it a rugose appearance. Rolled lead, on the other hand, has a very smooth surface.

The density of lead when pure is 11.445. The lead of commerce, however, is very rarely pure; it very often contains copper, iron, and even traces of silver, antimony, arsenic, sulphur, &c. Thus its density rarely rises above 11.352—one and a half that of zinc. Hammering does not appear to increase the density of lead, it diminishes it rather. It commences to fuse at 325° C.; before fusing it is covered with an iridescent pellicle of great beauty. As the temperature rises the colors disappear—at 335° C. it is in a complete state of fusion.

The prolonged contact of lead with another metal, will lead to its being destroyed by the electrical action which is set up. M. Détain quotes a case which came within his experience. The roof of a bathing establishment was covered with copper, but at one point lead was used in contact with the former metal. After a time the roof began to leak. A workman was called in. The lead was found completely oxidized; it had kept its form, but on being touched it crumbled into powder. The lead was likewise in contact with an oak plank, and its destruction was due to three causes: contact with the damp wood, the action of the vapor of water, and electrical action.

Lead is very rapidly altered by contact with damp plaster; sulphate of lead is then formed, which is a most energetic oxidizing agent. Saltpeter or niter also attacks lead very powerfully. Saltpeter is very often to be found in damp cellars, and upon the walls of wells; thus it is very commonly the destruction of the lead pipes in pumps, which under these attacks become perforated in many places. Again, lead is subject to the attack of certain insects which gnaw very minute orifices in it. It appears that old lead is not so liable to these attacks, and the inferiority in this respect of modern lead, is attributable to its being now-a-days too much refined, which, together with the rolling process, tends to weaken its structure. The texture of rolled lead is, so to speak, formed of a number of leaves, which are capable of being separated without much difficulty. Nevertheless, laminated lead is not the sole kind liable to these insect attacks. Marshal Vaillant not long since presented to the French Academy of Sciences some bullets which had been deeply eaten into in this way. Lead has about half the heat-conducting power of zinc. The power of lead, in this respect, is represented by 180, that of zinc by 363.

Nearly all the lead which is employed in the arts is extracted from the ore called galena or sulphide of lead. "This is the most abundant ore of lead; it may be, indeed, regarded as the only commercial ore of any value, if we except the carbonates, which are probably formed by the decomposition of galena."—("Ure's Dict.") This ore is found in all the lead producing districts. Thomson's analysis of galena gives:

Lead	85.13
Iron	0.50
Sulphur	13.02

Lead is found in almost every country. The beds are numerous, and next to iron the most widely spread; but the richness of these beds is very unequal. It is found almost in every kind of stratum, sometimes in thick and productive seams, sometimes only in "pipe veins," sometimes disseminated in grains.

England and Spain are at the head of lead-producing countries. England produces 70,000 tons; Spain 60,000 tons; Germany produces only about 10,000 tons; France produces but the insignificant amount of 200 tons annually, whilst to supply her wants she has to import about 80 times as much more.

Lead in its employment for Roofs.—The layer of lead upon a roof must be sufficiently thick to resist the influence of the coating of oxidized matter which will overspread its surface under the action of the atmosphere, and also to resist being torn and cracked by the force of the contractions and dilations which variations of temperature may cause it. The tenacity of lead is four times less than that of zinc, and at the same time its linear dilation is the same. In order then that lead may present the same resistance as zinc, it must be four times as thick. It is true that lead resists the destructive action of winds more successfully than zinc, on account of its greater weight and its better adherence to its supporting timber; but this very weight may prove an element of its early decay in the case of roofs which are of a very steep incline. We must also take into account that a roof covered with lead will cost six times as much as one in which zinc is used. Nevertheless, in making a comparison between the monetary value of lead and zinc, we must always remember that there is a vast difference in the ultimate intrinsic value of the two metals; lead after being used loses but little of its first value; whilst zinc loses considerably more than one-half.

If a lead roof is heavier and dearer than one of zinc, it is superior to it in appearance. It very quickly assumes a uniform dark aspect with grayish reflections; whilst zinc very slowly puts on a dirty black color, without any reflections. No experienced eye could be deceived as to the two metals, even at some distance. Lead has a rich, substantial look, whilst zinc is characterized by a mean, flimsy and cheap appearance, which must greatly detract from the beauty of any building of importance. The roof of Notre Dame, which is formed of lead, has a beautiful appearance, to speak of its color alone; the roof of St. Clotilde, on the contrary, formed as it is of zinc, has a poor and commonplace look. This fact is so fully admitted by the French builders, that in Paris, where, in house building, zinc is largely employed, those parts which are very prominent are colored black to resemble lead. This coat of oil paint, however carefully it may be prepared, adheres only badly to the metal, for in a short time it scales off and falls away in pieces. Another process has been tried with much effect, as it has been alleged. This is to paint the zinc with a hot solution of graphite, in water strongly charged with caustic and fixing substances, as for example, chlorate of potash and sulphuric acid; 14 parts of graphite, 1 of chlorate of potash diluted in 28 parts of sulphuric acid, commonly called vitriol. The whole of this compound must be gently heated, and watered to a consistency such as may be easily laid on with a brush. It is a good method, first of all, to wash over the surface of the zinc with a weak solution of sulphuric acid, which will cause it to take the paint more perfectly. The paint must be laid on hot.

Formerly, the lead was of a thicker kind than that now in use. This is one of the reasons why modern leaden structures are less durable than the old. Besides having regard for the proper thickness of the sheet of lead, we must always take into account the special qualities of the metal. Thus, when it is placed in position where it may expand with facility, we must, if possible, only nail it upon one end. The nails should be of a large head, and placed closely together. Lead should never be placed in contact with wet wood or damp plaster; and the proximity of another metal less oxidizable, should always be avoided. Finally, lead should never be subjected to the action of the vapor of water, because the water upon being condensed upon the surface of the metal is very much aërated, and in this condition acts very energetically upon lead, as we have already seen.

Soldering.—Lead is soldered by means of an alloy of that metal with tin, or simply by itself without the employment of any intermediary alloy, by the method known as "autogenous soldering." For the soldering of large and heavy work, the proportions of the alloy should be 30 tin and 70 lead; for lighter varieties of workmanship, 70 tin and 30 lead.

With respect to autogenous soldering (lead with lead, without using any intermediary alloy), it is only made use of in very great works, and in producing leaden vessels for the manufacture of chemical products, where the acids which act upon tin would very quickly destroy the ordinary solder.

This new method of soldering was invented by Count Desbassayns de Richemont. "Hydrogen gas is contained in a gasometer to which a flexible tube is connected, and air is urged from a bellows worked by the foot through another tube and on to the blowpipe where the hydrogen is ignited. By means of the flexible tubes, the flame may be moved up and down the line of any joint,

and the connecting medium melted."—(Ure's Dictionary.) In our naval arsenals this process has been largely employed. This kind of soldering renders the joint very strong, the junction being as firm as any other part of the surface of the metal. The process is capable of being used in all kinds of plumber's work.

In France, especially, lead roofs are formed in two ways: In the shape of slates and used in the same way, and in sheets. Leaden tiles are used only in the case of very pointed steeples, or domes of small dimensions, and in analogous circumstances. When sheet lead is used on steep roofs, it must be firmly secured, and at the same time it must be allowed the means of dilations. The new roof of the Cathedral of Notre Dame, at Paris, is made of cast lead. The celebrated Dome of the Invalides, in the same city, recently repaired, is likewise of cast lead. Both these roofs have a deservedly high reputation for beauty of appearance and excellence of workmanship.

THE IRON AGE OF SHIP-BUILDING.—The first large, square-rigged iron sailing-vessel ever built in this country was successfully launched August 5th, from the yard of Messrs. Harlan & Hollingsworth, at Wilmington, Del. This vessel, a bark, was built for Messrs. Tupper & Beattie, of this city, and is said by competent judges, who have examined her, to be in every respect equal to the best Clyde-built ships. She registers 700 tons, new measurement, is 155 ft. over all, 140 ft. keel, 31 ft. 9 in. beam, 11½ ft. depth of hold, is 7 ft. between decks, has all the modern improvements, and is very appropriately named the Iron Age. She has a yacht stern, upon which is placed the attractive and appropriate coat-of-arms of the State of New York. Her prow is sharp, and has for a figure-head the bust of an artisan, with a cold-chisel in one hand, and a hammer in the other, emblematic of his craft.

This vessel was built upon British specifications, and at a cost, we are assured, not exceeding the best Clyde-built ships, or, indeed, the cost of constructing a first-class wooden ship at this port at the present time, a special contract rate having been secured. In several essential particulars the Iron Age is an improvement upon any British iron ship which has visited our ports. The angle iron used in her construction is considerably heavier than that employed by the Clyde and Mersey builders; her ribs are from two to four inches closer together than British ships, while in her framing there has been no piercing or bursting of rivet-holes, which is something unusual in this class of vessels. In point of model, sailing qualities and carrying capacity have been judiciously blended. All the British iron ships that we have seen, are long and narrow, thus rendering it necessary to ballast them before receiving, and after discharging cargo. The Iron Age has sufficient breadth and curvature to obviate such a necessity. She has already been surveyed by the agents of the American and French Lloyds, and pronounced by them one of the best specimens of iron ships. When launched and ready for rigging her draught of water was only 4 ft. 11 in. forward, and 6 ft. aft, which is a foot lighter than a wooden ship of the same dimensions.

While the first cost of an iron ship is greater than that of a wooden vessel of the same size, the former, in the end, is much the more economical. It has been abundantly demonstrated that the use of iron instead of wood gives to the vessel greater strength, combined with lightness—two important considerations in ships. An iron ship, moreover, is not subject to the intense straining which is so severe upon the joints of the wooden vessel. The facility which iron gives in the construction of a vessel is much superior to that of wood, because there is no useless metal employed, and no filling is required. The power of iron to resist tension and compression is also much superior to that of wood. In the preparation of the material for the construction of a vessel, there is great economy of time and labor in the use of iron. The superior strength of iron vessels, and the tenacity of their frames in contingencies fatal to wooden vessels, are illustrated by a long practical experience. The use of iron increases the capacity of the vessel for stowage, thus rendering this kind of tonnage far more profitable, to say nothing of durability. A first-class wooden ship will rate A 1 for but nine years, while a first-class iron ship will stand the same rate for twenty-one years. And the iron ship, with no unforeseen casualty, will be good property long after a modern wooden ship has gone out of existence.

The days of wooden ships, it is safe to conclude, are about numbered. In Great Britain, iron has become the standard ma-

terial for ship-building, and in other maritime countries a similar change is beginning to take place, so that in another decade, probably, wooden ship-building will be out of date. Although the United States, for obvious reasons, is behind the leading nations of Europe in this branch of industry, it may safely be taken for granted that we are not likely to remain long in the background. We want cheaper materials to begin with, and if Congress cannot frame a law for the benefit of ship-builders without exciting a conflict of interest among other classes of home producers, it must inaugurate prompt reform in national finances, such as shall bring down the cost of production to its natural level. Something must be done, without longer delay, to resuscitate an interest that has been, in years gone by, the bulwark of our commerce, and to rescue our valuable carrying trade from the flags of other nations.

The Iron Age is the third iron sailing-vessel ever built in the United States, the other two being the schooner Mahlon Betts, built at Wilmington, Del., and the iron brig Novelty, recently built by the Atlantic Iron Works, Boston, for carrying molasses in bulk. Both are much smaller than the vessel launched at Wilmington last week.

Wilmington has important advantages over any other American port in this branch of industry. She has iron and coal in abundance at her very door, together with long years of experience. The firm who built the Iron Age have built upwards of two hundred iron steamers, varying in size from 300 to 1,500 tons. They have built for one firm alone, twenty-one steamers for the Gulf trade, and they have been thirty-three years maturing their plans to carry on this important branch of industry. They employ at present 600 hands, but have facilities for employing more than twice that number, should their business warrant it.—*N. Y. Shipping List.*

RESISTANCE OF ROADS TO TRACTION.—The following results of the experiments of Sir John McNeill in regard to traction on roads of different kinds, are pretty generally accepted as accurate:

Resistance in pounds per ton on different roads.

Iron floor	8 lbs. per ton.
Stone tramway	20 lbs. per ton.
Paved road	36 lbs. per ton.
Macadamized road	44 to 67 lbs. per ton.
Gravel	150 lbs. per ton.
Soft, sandy and gravelly soil	210 lbs. per ton.

STEAM-ENGINE PERFORMANCE.

From "Engineering."

Since the publication in a recent number* of the particulars of the experiments made by Messrs. Farey and B. Donkin, jr., on an engine at Messrs. B. Donkin & Co.'s works at Bermondsey, we have received from Mr. John Pinchbeck the details of a trial conducted by him some years ago of a single-cylinder engine constructed by the Reading Ironworks Company, then Messrs. Barrett, Exall & Co. In this trial the temperatures of the water supplied to, and thrown off from the condenser were accurately noted, and the quantities both of the condensing water and of the water evaporated were carefully weighed, as was also the fuel used. In order that the quantity of water evaporated might be ascertained with accuracy, the water was weighed before filling the boiler, and on the experiment being completed the boiler was blown off, and the water thus blown off also weighed. The difference between these first and final weighings had, of course, to be added to, or subtracted from the weight of the water supplied to the boiler during the trial, in order to get the true evaporation. The weighing of the water discharged from the condenser was managed as follows: A wooden tank, measuring about 4 ft. × 4 ft. × 4 ft., was placed on the table of a weighing machine and accurately balanced, and weights amounting to one and a-half tons were then placed on the scale beam. The water in the condenser was then run into this tank until the weights we have mentioned were lifted, when the communication with the hot well was shut off by a sluice, and another sluice opened which allowed the water to run out of the tank. While the main tank was being emptied, the water discharged from the hot well was received in a small auxiliary tank, which was, of course, emptied into the main tank as soon as the latter was ready to be refilled. The number of times that the main tank was filled and emptied was, of course, registered, and the weight of water discharged from the condenser was thus obtained very accurately. Altogether this trial of a single-cylinder engine is one which forms an interesting comparison with that of the engine of the double-cylinder class, of which we gave the details last week. The particulars of Mr. Pinchbeck's experiments are as follows:

* See V. N.'s Mag., Aug., p. 693, and Sept., p. 787.

Description of Engine.—Horizontal high-pressure condensing. Cylinder 21 in. in diameter, with 30 in. stroke. The cylinder and covers steam-jacketed, steam being supplied direct from the boilers, and means being provided for getting rid of the water resulting from the condensation of the steam. Distribution of the steam effected by slide-valve with adjustable expansion valves at the back, worked by separate eccentric. During the trial the cut-off took place at 3¼ in. of the stroke.

Boiler.—Cornish, 22 ft. long, 5 ft. in diameter, with single flue 32 in. in diameter. The boiler was fed from the hot well, the water being pumped through a heater fixed in the boiler flue.

Duration of experiment.....	10 hours.
Quality of coal used.....	Duffryn steam coal.
Quantity of coal used.....	11 cwt.
Quantity of water evaporated,	1,108 gallons.
Quantity of water evaporated per lb. of coal	9 lbs.
Pressure of steam.....	50.9 lbs. per sq. in.
Mean vacuum	27 in.
Quantity of water thrown off by condenser per minute.....	410 lbs.
Mean temperature of water used for condensing	38°
Mean temperature of water as discharged from condenser..	82°
Revolutions of engine per min., by counter	60.03
Power developed (indicated)..	47 H. P.
Power developed, as measured by brake.....	40 H. P.
Consumption of coal per hour per indicated horse-power..	2.6 lbs.
Consumption of coal per hour per dynametrical horse-p'r,	3.06
Ratio of expansion, allowing for clearance, etc.....	1:8.6

It will be seen, from the above particulars, that the mean vacuum and the indicated power developed, are practically identical with those obtained during the trial of Messrs. B. Donkin's engine, and the consumption of coal per indicated horse-power per hour is also the same. It will be remarked, however, that the pressure of the steam is 10 lbs. higher than during Messrs. Farey and Donkin's trials, and that—owing probably to a better quality of coal being used—the evaporation of water per pound of fuel was higher than in the case of these last-mentioned experiments, being 9 lbs. against 8.72 lbs., and this circumstance should, as we pointed out in our previous article, be taken into consideration in comparing the performances of the two engines. Adopting the far better method of comparison proposed by Messrs. Farey and Donkin, and already fully described by us, we find that the quantity of heat discharged into the condenser, per indicated horse-power per minute, was more than 16 per cent less in the case of Messrs. B. Donkin and Co.'s engine, than in that of the engine tested by Mr. Pinchbeck. Thus, in the latter instance, the average quantity of water discharged from the condenser was 410 lbs. per minute. This quantity of water was heated from 38° to 82°, or 44°; and multiplying 410 by 44, we get 18,040 as the number which, divided by the indicated horse-power developed, gives Messrs. Farey and Donkin's "constant." In the case of the engine tried by Mr. Pinchbeck, this "constant" is $\frac{18,040}{47} = 383.8$, while the "constant" obtained during the trial of Messrs. B. Donkin & Co.'s engine was 322.87, or 16.2 per cent less. Considering that the quantity of fuel burnt, per indicated horse-power per hour, was the same in the two cases, and that the evaporative value of the fuel varied but about three per cent, the above difference of 16.2 per cent in the quantities of heat respectively received by the two condensers, appears, at first sight, somewhat difficult to account for, even if we suppose that in Mr. Pinchbeck's experiment the hot well received all the water discharged from the steam-jackets. If, however, we analyze Mr. Pinchbeck's experiment more minutely, we shall find that the various results agree very closely, and that any errors of observation which may have occurred, must have been very small. If this had not been the case, we might have supposed either that the quantity of water evaporated must have been somewhat greater, or the quantity of condensing water must have been less, or have been less highly heated during its passage through the condenser. Thus, 1,108 gals. of water were evaporated during the ten hours = 1,108 lbs. per hour = 18.46 lbs. per minute, and, of course, the same quantity of water returned to the boiler as feed at a temperature (the feed being taken from the hot well) of 82°. The total heat of steam, at a pressure of 52 lbs. above the atmosphere, is 1,205.4°, and the quantity of heat withdrawn from the boiler, per minute, was thus $(1,205.4—82) \times 18.46 = 20,737.96$, or, say, 20,738 thermal units. If now we suppose (as was probably the case) that the water discharged from the steam-jackets found its way into the hot well, the manner in which the above quantity of heat would be disposed of would be as follows: Subtracting from the 410 lbs. of water discharged from the condenser per minute, the 18.46 lbs. resulting from the condensation

of the steam, we get 391.54 lbs. as the quantity actually raised in temperature 44°, and $391.54 \times 44 = 17{,}227.76$, or, say, 17,228 thermal units of heat are thus accounted for. Again, the quantity of heat actually converted into work would be $\frac{33{,}000 \times 47}{772}$ = 2,009 units, and there would thus be but 1,501 units to be accounted for by losses by radiation, etc. The summary would be as follows:

	Thermal units per minute.
Converted into work.....	2,009
Imparted to condensing water....	17,228
Lost by radiation, etc.....	1,501
	20,738

We have said that the difference of 16.2 per cent in the "constants" obtained in the two cases we have considered is, under the circumstances, somewhat difficult to account for; but it is no doubt due to the fact that, not only was the expansion carried to a less extent, but both the initial and final temperatures of the condensing water were, in the case of the engine tested by Mr. Pinchbeck, lower than in the case of the engine at Messrs. B. Donkin & Co., although the vacuum was the same in both cases. Of the effect of such differences of temperature and of the degree of expansion on the "constants" proposed by Messrs. Farey and B. Donkin, jr., we intend to speak fully on an early occasion; and we shall then show that the fact of such differences having the effect we have stated, in no way diminishes the value of the "constants" as standards of comparison, but, on the other hand, rather increases it.

FRENCH MILITARY TELEGRAPHS.

Translated for "Engineering" from "La Télégraphie Militaire," Paris, 1869.

The following are details of the military electric-telegraphic apparatus used in the experiments in the camp at Chalons, last summer:

Electric Telegraph.—For military purposes it is desirable that the apparatus should not only be simple in itself, but should be capable of being used in connexion with the permanent lines of telegraph already established. Keeping these ends in view, a modification of Morse's recorder, constructed by M. Duguy, from designs furnished by the Bureau des Télégraphies, and known as Le Poste Militaire, was adopted and found to answer well. This apparatus is contained in a box, to the bottom of which it is secured by slides. The manipulator is placed on the right of the small shelf supporting the recorder; on the left are the galvanometer to show the strength of the current, and a paratonnère to protect the operator from the shock of unforseen accumulations of electricity in the wires in stormy weather. The sides and front of the box fold down, so as to permit of the instrument being used without necessitating its removal from its case.

The connection between the stations was kept up partly by wires, partly by a cable laid along the ground.

Wires.—These were of copper, 1.6 mil. in diameter, weighing 22.5 kilog., and costing about 100 francs per kilom. This wire proved an excellent conductor, and, with care, could be used with intervals of 200 and 300 m., or even more, between the supports.

Cables.—Several kinds were tried. In the last experiments the cable was formed of a core of five annealed copper wires, bound round with white cotton thread, over which was a coating of gutta-percha, and then a layer of oakum, the whole being bound round twice with cotton tape steeped in vulcanized india-rubber. It weighed 35 kilog., and cost 320 francs per kilom. It was perfectly insulated, and a good conductor. When laid along the ground it suffered little from wheels and the feet of horses passing and repassing over it. But it had serious defects. It was rather too large in its diameter, and very weak, stretching sufficiently to injure the core with a strain of 30 kilog., and breaking with one of 40 kilog. The wires of the core were so fine as to be frequently cut through in removing the covering for the purpose of splicing.

Supports.—The wires were supported on light staves called lances, 3 m. 80 c. in length, 200 of which made a military wagon load. They were sunk 12 in. in the ground, and weighed up with wooden pickets. Where the line made an angle, the lances were strengthened with guy-ropes, known as haubans, attached to iron pickets. The lances could be lengthened by attaching two or more, end to end, by means of rings called anneaux de rallonge, fitted with clump screws.

Insulators.—With spires of india-rubber made hollow so as to fit over the end of the lances, and surmounted by a small cylinder

of the same material. The wires were attached to the insulators by a couple of turns.

Iron cramps were also supplied which could be driven into the ground, or into the walls and trees *en route* to support the cable when used in place of wires.

For the transport of this *materiel* four-horse tilted wagons were provided of three descriptions. Each wagon was supplied with lamps arranged for external or internal use, and carried a distinguishing flag marked with a T in front. The draught in "marching order" is not stated, neither are the kinds of timber used in their construction of the wagons specified. The voiture poste, or traveling telegraph office, was in two compartments—the front serving as an office, the rear containing reels for the wire or cable. On the left of the front compartment (which was furnished with small windows) was a table, to the top of which was screwed the case containing the telegraph. On the right was a seat for two operators, under which were placed the batteries. The "earth connexion" was maintained by means of a wire communicating with the iron axle-tree, which in its turn was connected by means of the brass axle-tree boxes, and a metal rod running along one of the spokes with the tyre of the wheel. The connexion was thus independent of the movements of the vehicle. Where a good "earth" could not be found the wheels were wetted from time to time, or the wire was detached from the axle-tree, and tilted to a hollow iron picket provided with holes and filled with water,* which was driven into the ground under the wagon. This could of course be done only during a halt.

The other wire was connected with the metal work supporting the reels, and through it with the iron cheeks of the latter, against which one end of the wire or cable was clamped. These two wires, like those connecting the telegraph with the batteries, were of copper coated with gutta-percha. The contact was secured each time the telegraph was put in work, by means of small brass button-headed screws, known as bomes, serrés fils, and serrées lames.

The sides of the front compartment were fitted up with drawers and pockets for carriage of spare stores, etc. The hind compartment held eight reels, four on either side. The cores, cheeks and axles of these reels were of iron, the other parts of wood. The axles revolved in sockets fixed on two iron rails running along the sides of the compartment, and known as chemins de fer. Some ingenious arrangements were provided for regulating the motion of the reels, and protecting the hands of the men working them.

Each reel carried 5 kilom. (130 kilog.) of wire if required. But as 90 kilog. had been found to be about the maximum weight of a reel to be perfectly manageable, it was considered preferable to have 2 to 3 kilom. only on each, or 1 kilom. of the cable above described. The total interior length of the voiture poste was 3 m. 20 c.

The chariot poste-bobine, or wire wagon, was similar in exterior to the above, but somewhat longer, the interior length being 3 m. 90 c. It carried twelve reels, six on a side, each having 3 kilom. of wire. The lances, thirty or forty in number, were racked longitudinally between the two rows of reels. Each wire wagon carried also a supply of pickets, wood and iron, insulators, ropes, &c., &c.

One voiture poste with its accompanying chariot poste-bobine was estimated to carry a length of wire equivalent to an average day's march of 20 kilom. (or 12½ miles.) The poste centrale resembled the voiture poste without the reels, the whole interior being fitted up as a telegraph office. Two ateliers, or squads, each consisting of one sergeant, two corporals, and twelve soldiers —exclusive of drivers, buglers, &c.—were told off to each voiture poste with its accompanying wire wagon.

In addition to the arrangements above described, an equipment for mountain service was provided on the following plan—this was called the poste roulante:

A mule or pack-horse carried two panniers, one on each side, one holding the telegraph apparatus, the other the battery, the weight of the two being equal; each case being also provided with drawers for the carriage of insulators, cramps, &c., so arranged as to allow of their being opened without removing the panniers from the mule's back. Across the top was packed a small light square tent, to serve as an office, and a tripod table for the apparatus, an iron picket for "earth connexion," and a bag of tools. A second mule or horse carried two reels with their supply of wire, slung pannierwise across a pack-saddle by means of chains.

* A supply of water was carried in a small gutta-percha cistern fitted in rear of each wagon.

As the unwinding of the reels on the mule's back would not only alarm the animal, but also disturb the balance of the load, a small wheelbarrow was also provided, light enough to be lifted up in the hands if necessary, and fitted to receive one pair of reels. The mallet required for driving the picket could be used as a handle, so as to enable a man to push the contrivance before him without stooping.

This little barrow often proved of great service, even with the wagons, in passing over broken ground. In crossing streams, too, it could be placed in the stern of the boat, thus greatly facilitating the "paying out" of the cable.

The operation of laying down the line was conducted as follows: A wire-wagon, followed by its voiture poste, marched first, both wagons halting from time to time to allow of the working party keeping a little ahead of them. The signals for advancing and halting were given with a whistle. The working party usually consisted of one atelier (15 men) divided into three subdivisions, and without arms or packs.

The sergeant marched at the head, marking out the line foot by foot. The first subdivision followed, digging the holes for the lances usually at 50 to 60 m. apart, or when cable was used, digging the little trenches to receive the latter at points where roads had to be crossed, fixing the cramps for its support at distances varying in accordance with the nature of the ground, &c. The second party unwound the wire or cable, making the splices and joints. The third then attached the wire to the lances fixing the latter; or laid out the cable, filling in the trenches where such were made for it, and finishing the line generally.

The work was very arduous. The average rate obtained on the most favorable ground was two kilom. the hour with suspended wires, and five kilom. with cable. In passing villages, &c., double the above time proved requisite.

For taking up the line, five or six men marching in inverse order were sufficient. The rapidity with which this manœuvre was executed equaled and sometimes exceeded that of ordinary route marching.

In joining the lengths of cable, the covering was first removed and an elastic india-rubber tube slipped over one length, the wires were then spliced and the india-rubber tube drawn over the joint and secured by tying down the ends firmly with twine. This was found to answer perfectly; but as the tying process took up some little time, small cylinders were sometimes substituted for the india-rubber tube. These contained two india-rubber discs having holes in them for the passage of the cable, and hollow screws at each end working against them. The screws were made hollow so as to allow of the passage of the cable through them. The splice was made in the ordinary way, the tube drawn over the joint and the discs compressed round the cable by the action of the screws. A joint could be thus made in thirty seconds. It was found, however, that the vibration of the cable loosened the screws and allowed water to leak into the joints.

The experiments at Chalons were conducted by a corps formed provisionally of detachments of the different regiments in the camp, under the superintendence of some officers of the Etat Major, assisted by some *employés* of the Administration des Télégraphes. They were of various kinds. On one occasion when a series of manœuvres were executed in presence of the Emperor, parties of the telegraph corps accompanied each division. Communications were kept up between the divisions and the head-quarters, and with the telegraph station at Mourmelon through which despatches were transmitted to Paris. On another occasion a party of the corps, with a voiture poste and wire-wagon, accompanied a cavalry reconnaissance to a distance of 8 kilom. from the camp. They laid down a line of telegraph, transmitted several reports to camp, and took up the line again in time to re-enter the camp with the cavalry.

The crowning experiment was made on 30th July. A party of the telegraph corps, consisting of four officers, two civil *employés*, 70 men, five wagons, including a forage cart with the baggage, and 30 horses and mules, marched from the camp at midnight with provisions for two days. A line of wire, 7 or 8 kilom. in length, had been established the evening before. The night was very dark. The party arrived at its destination at 1 A. M., and immediately commenced the prolongation of the above line, with the aid of lanterns. By 6 A.M., 24 kilom. of line had been completed, and guards established along it. The party bivouacked at Perzy. The line remained in use 36 hours. At 5 A. M., on 1st August, they started again for Chalons, and re-entered the camp at 10.30 A. M., having brought in the whole of the line of telegraph.

These experiments were considered highly satisfactory. We learn, however, that the Imperial Government has not considered it expedient to establish a separate corps for telegraphic purposes at present; the *materiel* has accordingly been made over to a company of the Corps du Génie, by whom the duties are in future to be performed.

WHITE PIG-IRON IN THE BESSEMER PROCESS.

By Dr. Adolph Schmidt.

It has been found by numerous experiments, made and repeated in all iron and steel making countries, that white or even mottled pig-iron cannot be worked to advantage in the Bessemer converter. The most celebrated brands of Bessemer pig are gray and graphitic to such an extent as to be almost unfit for foundry purposes. When white or mottled iron is used in the Bessemer process, the first or slag-forming period, which with good working irons, lasts from nine to twelve minutes, passes over in five or six, and as the duration of the second and third periods is generally unchanged, the whole charge is thus shortened about five minutes. In the second or boiling period of the process, when the carbon is in full and rapid combustion, and a bright flame with sharp outlines is rushing through the mouth of the converter, white iron causes vehement eruptions, and thereby considerable losses of metal.

During the third or finishing period, the flame appears then mostly dull and pale, indicating a comparatively low temperature of the metal in the converter. The reaction of the recarburizer is slow and weak. The final product, though sometimes of a bright appearance in pouring, chills easily in contact with less hot objects. Parts of it stick to the interior walls of the converter, especially near its mouth, and a heavy scull in the ladle is unavoidable. It is evident that a favorable percentage of ingots cannot thus be obtained.

The product is, besides, not of a very good quality. Though the white iron may be good and pure, the Bessemer metal made from it shows frequently this peculiarity—that it can be worked perfectly well at a red heat or at a white heat, but that it cracks and even crumbles to pieces when hammered at an intermediate or yellow heat. This deterioration by a yellow heat goes in single instances so far as to make a bar, which is heated yellow, break off in being simply bent. This peculiarity, which no other but Bessemer metal ever shows, is often the consequence of a cold charge. It has been called "shortness" in Sweden and Austria, where it sometimes occurs with the best brands of iron. After the analogy of the word "red-shortness," which is in general use, "yellow-shortness" would perhaps be a more appropriate expression.

The effects above described are produced by most white or mottled pig-irons when subjected to the pneumatic process, the spiegeleisen not excepted.

The short duration of the charge, and the coldness of the product, leads us to suppose that a lack of carbon might be the cause of all this. If not only carbon is taken into consideration, but also silicon, sodium, potassium, aluminium and other ingredients which, at moderate temperatures, have more affinity for oxygen than carbonhas, this supposition appears to be well founded. For, though a good white iron contains generally nearly or quite as much carbon as a gray iron, the latter, however, being made at a higher temperature, always contains a much greater quantity of silicon and other matters which require a high temperature to be reduced, and the total percentage of carbon and silicon, etc., is always higher in a good gray iron than in a good white iron, provided that the latter has not been made white artificially by sudden cooling in water or in iron molds.

When an iron containing a considerable amount of silicon is worked in the Bessemer converter, four-fifths of the silicon and only one-third of the carbon are burnt during the first period, which takes over one-half of the time of the whole charge. It is seen, from this fact, that the greater part of the carbon is saved for the latter half of the charge, and can then exert its full heating power on the iron, the latter being heated up slowly and gradually by the previous combustion of the silicon. When, on the contrary, a pig-iron without silicon is converted, the carbon enters very soon into full combustion. The difference between the temperature of the gases produced and that of the molten iron is then so great, that the rapidly escaping gases carry off uselessly a great quantity of heat which otherwise might benefit the iron, and the greater part of the carbon is consumed before the time when the heat would be most required and most useful.

The heat produced by the burning silicon is also more fully utilized than that produced by the burning of the carbon, because the product of the combustion of silicon, viz: silicic acid is not gas, but a solid substance, and does not escape rapidly, but combines with the slag, and is thus retained in the converter, where it has ample opportunity to communicate its surplus heat to the metal.

It seems, therefore, that not exactly a lack of carbon alone, but that a lack of "fuel" in general, that is to say, too small an amount of all the substances which by their combustion produce the heat in the Bessemer process, is the real cause why white or mottled pig-iron cannot be worked to advantage. Guided probably by these considerations, Mr. Edward Stockher, general director of the Imperial Iron and Steel Works at Neuberg (Styria), has conceived the idea of adding fuel to the Bessemer charge in case the pig-iron should not be sufficiently gray to make a hot charge by itself. He proposed, and tried with success, blowing charcoal dust into the converter.

The first trials were made in 1867, and since that time charcoal has been used regularly in almost all the charges. At Neuberg, the pig-iron is generally run from the blast furnaces into the converter without being remelted. The iron must be highly graphitic to make hot Bessemer charges and to produce a good metal. To insure this desirable effect, independently of the unavoidable little irregularities in the blast furnace, a great amount of charcoal had to be used for the production of the pig-iron, and the furnaces had to be conducted with the utmost care. Since the introduction of Mr. Stockher's method of blowing charcoal dust into the converter, a saving of 22 cubic ft. of charcoal is effected per ton of iron without injuring the quantitative or qualitative results of the Bessemer process. A sample of the pig-iron is taken and inspected before each charge, and the less gray and graphitic it is found to be, the more charcoal dust is blown into the converter. When this operation is properly regulated and managed, the charcoal dust is burnt in the converter below the surface of the iron, and increases the heat to such an extent that excellent results are obtained from mottled pig-iron. The quantity of charcoal dust used varies from 60 to 200 lbs. in a charge of three tons.

According to a communication, received through the kindness of Mr. Edward Juchelka, at Neuberg, the apparatus used for the purpose consists of an upright wrought-iron cylinder, ending below in a narrow pipe by which it is connected with the main blast-pipe. The connecting pipe is provided with a cock. The required quantity of charcoal dust is put into the cylinder from above. The cock in the connecting pipe being closed, the cylinder is then shut tight at the top by an iron plate, which is screwed on to it. When the blast is let on and the converter is turned up, the cock is opened. The charcoal dust is then blown into the converter together with the air. This is distinctly noticed by the appearance of the flame. When, after some time, the blast ceases to carry charcoal dust into the converter, as it often happens, this is also noticed at once and easily helped. The blast valve is then shut down entirely for a few seconds. The pressure of the blast depending during this time on the pressure in the accumulator only, sinks rapidly from 20 lbs. down to 14 or even to 12 lbs., and when, after this, the valve is reopened, the blast continues to draw charcoal dust from the cylinder. As a general rule the pressure of the blast must be kept pretty high, because with a low pressure the charcoal is not burnt in the converter below the surface of the molten metal, but is carried through unchanged, and burns afterwards uselessly in the stack.

In November and December, 1868, some attempts were made at Neuberg to use graphite instead of charcoal dust, according to the suggestions of Mr. H. Brunner, teacher at the Leoben Mining School. As highly graphitic pig-irons work best in the Bessemer process, Mr. Brunner thought that graphite might be more effective than charcoal when blown through the iron. But this idea is based on the probably erroneous supposition that gray pig-iron, even when in a molten state, contains a considerable amount of carbon in the shape of graphite. However, all the well-known phenomena connected with the chilling of pig-iron, seem to prove that in gray pig-iron, when melted, nearly all the carbon is combined or dissolved, and that it is not present then in the shape of a solid graphite. When gray pig-iron is melted and poured into cold water, it appears white, because sufficient time is not left for the carbon to separate from the iron and to crystallize as graphite. The iron is then retained in about the same

molecular condition and construction which it had in its fluid state.

A report on the experiments made with graphite, by Mr. J. Schmiedhammer, the chief engineer and technical manager of the Neuberg works, is published in "Oestr. Zeitschrift," 1869, No. 23. This report is the more interesting, as it compares the results obtained with graphite with those obtained by the use of charcoal dust.

Mr. Schmiedhammer reports as follows: "The experiments were made in the small converter, to get the charges as small as possible. The graphite used was of the best quality, and finely pulverized. In the first charge 50 lbs. of graphite were blown into the converter, that is, about one per cent of the pig-iron. In the three following trial charges, two, three, and four per cent of graphite were used. Immediately after the third, and again after the fourth trial charge with graphite, another charge was made with the same pig-iron, and under the same circumstances, except that charcoal dust was used instead of graphite. The pig-iron was taken from the available stock, and was melted with coke in a cupola furnace. The pigs were carefully selected and of uniform appearance. The iron was mottled and of such a composition that it became white when cast into iron molds.

The results of the six experimental charges (four with graphite and two with charcoal dust) are contained in the following table:

In comparing the results contained in the above table we are led to the following conclusions: Graphite, when blown into the converter, does not remedy to a lack of carbon in the pig-iron. The graphite seems to burn but incompletely, if it burns at all. This fact is also indicated by the flame, which has a more or less dull and cloudy appearance in proportion as graphite is used.

Graphite does not lengthen the first period of the process. This is, however, done by the charcoal dust, the use of which therefore counteracts the disposition of mottled pig-iron towards producing vehement discharges from the mouth of the vessel.

Graphite is not able to make a charge with mottled iron hot enough, not even when the iron is very hot in being run into the converter.

The product obtained with graphite has all the qualities of a metal resulting from a cold charge. It chills easily, and is short at a yellow heat. The slag is pasty and tough, and not very fluid. Great losses are caused by discharging and sculling.

With graphite the pressure of the blast has to be diminished considerably during the second period, to avoid too copious discharges. This is necessary but to a very small extent when charcoal dust is used.

The charges, Nos. 905 and 950, made with mottled iron and charcoal dust, were as regular and good as if gray iron had been used. The duration of the first period was

Date.	No. of charge.	Pig-iron.			Products.							Percentages.					Duration in Minutes		Graphite or charcoal dust used.	Time during which the fuel was blown into the vessel.
		Number.	Run into vessel.	Recarburizer.	Ingots. — Quality.			Scrap.	Scull.	Thrown out of the vessel.	Grade of hardness.	Ingots.	Scrap.	Scull.	Thrown out of the vessel.	Loss.	1st period.	Whole charge.		
					1st.	2d.	3d.													
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.									lbs.	min.
Charges with Graphite.																			graphite.	
Nov. 27..	891	7	4,800	240	.....	.....	3,595	50	75	400	VI.w	71.33	.99	1.48	7.93	18.26	5	17½	50	6
Nov. 28..	895	7	4,800	140	.....	.....	2,375	20	600	900	VII	48.08	.40	12.14	18.21	21.15	4	17	100	4½
Dec. 1..	904	7	4,600	210	.....	.....	3,830	30	140	200	VII	79.63	.62	2.91	4.15	12.68	6	20	150	7
Dec. 12..	949	7	4,800	290	.....	4,010	.....	20	70	180	VI	78.78	.39	1.37	3.53	15.91	5	19	200	6
Charges with Charcoal dust.																			charcoal.	
Dec. 1..	905	7	5,050	210	4,720	.....	.....	20	....	....	VII	89.22	.38	.....	.....	10.39	14	27	200	12
Dec. 12..	950	7	5,400	290	5,020	.....	.....	20	....	....	IV	88.22	.35	.....	.....	11.42	11	22	200	10

In charge 895, a small quantity of pig-iron was used for recarburizing, because the loss of metal from discharging was considerable.

In charges 949 and 950, a large quantity of pig-iron was used for recarburizing, with the intention to produce a harder grade of metal.

normal. The metal proved to be of good quality. The slag was very fluid."

From this report, and from the fact that Mr. Stockher's method is in continual and successful use at Neuberg, we may infer that to work mottled iron by the Bessemer process, fuel is required, and that this fuel must be such as to burn readily with air at a moderate temperature.

Some kind of gaseous fuel, for instance, ordinary illuminating gas, when used with the necessary precautions against explosion, would perhaps make it possible to convert even a white pig-iron to advantage into Bessemer metal. The economy of such a proceeding would depend on local circumstances.

MODERN ORDNANCE.

From the opening address of Sir WILLIAM G. ARMSTRONG before the Institute of Mechanical Engineers, at Newcastle.

When battles were fought hand to hand, war, so far as mechanics are concerned, was an affair of muscular force, and was in that form the most sanguinary, because combats were the most close. When other forces were called into play, inventive appliances became necessary, and these, as they have advanced, have more and more widened the distances separating combatants, and have thus operated to prevent that greater sacrifice of life which would otherwise have resulted from the employment of more destructive weapons. It is, therefore, not to be supposed that future wars will be rendered more murderous by the intervention of the engineer; on the contrary, we may fairly anticipate that the more the element of intelligence supersedes that of animal force in military struggles, the more will the barbarity of war be mitigated. Science naturally sides with civilization, and tends to establish a supremacy over barbarism, and we find this tendency, as in the case of the late Abyssinian war, not only giving overwhelming superiority to the cause of civilization, but deciding the issue with the least possible waste of life. But whatever our sentiments may be in regard to war, it would be absurd to contend that we ought to withhold from invention, when the object sought to be attained is the destruction of life and property. It is our province, as engineers, to make the forces of matter obedient to the will of man, and those who use the means we supply must be responsible for their legitimate application.

It will be in the recollection of the members of this institution who visited the Elswick works on the occasion of the last meeting at Newcastle, that two or three small breech-loading rifled guns were shown to them as novelties deserving their attention. Those guns had then very recently received the recognition of the British Government, and may be regarded as the small beginnings of a system of ordnance which has since attained a very extensive adoption in this and other countries. It was not until the principle of rifling was adopted for military firearms, that these weapons presented much scope for the mechanician's art, but the introduction of rifling, and the change in the form of the projectile from a sphere to a pointed cylinder, brought about a complication of new conditions which it has required years of research and experiment to meet and satisfy. Passing over the subject of rifled small arms, which of late has called forth a great amount of ingenuity and skill, I will speak of artillery, as being that division of gunnery with which I am personally connected.

The most important of all the considerations affecting modern artillery, is how to obtain the strongest possible tube with the least possible weight. Before I state my views as to the best mode of attaining this object, I must call attention to the conditions affecting the force to be resisted. When a charge of powder is fired in a gun, it is converted into gas at an exceedingly high temperature, and the pressure exerted is due, even in a greater degree, to the heat than to the quantity of gas produced. But the heat evolved is not wholly realized in augmentation of pressure, a considerable part of it being absorbed by the material of the gun. The heating of a gun by firing is an effect familiar to every one, and it affords an indication both of the quantity of heat abstracted from useful effect, and also the amazingly high temperature of the gas before it escapes from the gun. Fifty rounds fired in quick succession from a field-piece, will make it so hot that it cannot be touched. Since the flame is only in contact with the bore for about the 150th part of a second at each discharge, it follows that the aggregate duration of the flame contact by which the gun is thus heated in fifty rounds, only amounts to one-third of a second. The thin film of heated matter deposited on the surface of the bore at each discharge, contributes, in some measure, to this rise of tem-

perature; but we may regard the acquisition of heat from this source as fully neutralized by the cooling of the gun in the intervals occupied by loading. Thus, then, you will be able to appreciate both the intensity of the heat of the gas and the extent of the waste by absorption. In small guns the area of absorbing surface surrounding the charge is greater in relation to the mass of the charge, than it is in larger guns. Therefore, the waste caused by the heating of the gun is also relatively greater, and the gas never attains either the same heat or the same pressure in the smaller weapon as in the larger. But the greater heat attained in a large gun, adds to pressure not only directly, by expanding the gas, but indirectly, by accelerating the combustion of the powder. The powder must be regarded as fuel burning in a furnace, and the hotter the furnace is the quicker the fuel will burn. You will perceive, then, that the pressure of powder-gas per unit of surface is augmented by increasing the size of the gun, apart from all considerations regarding the projectile. But the pressure of the gas is further increased in large rifled guns by the great length of column represented by the projectiles. The resistance increases with the length of the projectile, and the pressure rises with the resistance. Augmentation of pressure is also caused by the rifled projectile having to acquire motion of rotation in addition to that of translation, though the increase of resistance, and of consequent pressure due to this cause, is not so considerable as is commonly supposed. For these various reasons, the introduction of the rifled principle, and the enormous increase of size demanded in modern ordnance, combine to intensify that pressure to a degree which taxes our utmost resources to control. The limit of the pressure actually reached in rifled guns of the largest size, when fired with English service powder, is not yet fully ascertained, but it is probably not less than 70,000 lbs. on the square inch.

Now comes the question of what construction is best adapted to resist so inordinate a strain. It was long since demonstrated by Professor Barlow, that a cylinder, to possess the greatest possible resistance to a bursting force, must, when out of action, have its interior in a state of compression, and its exterior in a state of tension. He further proved it to be necessary that the internal compression should diminish in an outward direction, and the external tension in an inward direction, up to an intermediate zone of neutrality. If these conditions were neglected, he showed that in a very thick cylinder, the material forming the interior portion would be stretched to the breaking point before the exterior portion acquired any considerable tension. The interior, therefore, would be overstrained, while the exterior would be understrained, and the aggregate resistance would necessarily be less than if all parts were doing full duty. This reasoning is the foundation of the argument in favor of built-up guns, in which every layer of the material is stretched upon the layers beneath, and the finished structure is in the condition of internal compression and external tension, demonstrated by Barlow to be that of greatest strength.

The Americans have endeavored, with partial success, to realize the advantage of this principle in cast-iron guns, by cooling the inside first, and allowing the external portion of the metal to shrink upon the hardened interior. The Rodman cast-iron gun is made upon this principle, and considering the nature of its material, has, in some examples at least, exhibited great power of resistance, though not sufficient to enable it to be used for heavy ordnance in the rifled form.

Where forged material is used for the fabrication of guns, this condition of outward tension and inward compression is unattainable except by the application of the material in successive layers, each stretched on those below. Considerations of economy or convenience may supervene to reduce the number of layers, as in the Fraser modification of coil-made guns; but theoretical perfection will be most nearly reached in that gun which is composed of the greatest number of layers. To attempt to forge large guns in single blocks, is a direct violation of established theory, and the general failure which has attended such attempts, is a practical proof of the truth of the theory.

The next point to consider is the best kind of material for the fabrication of guns. In determining this question, the choice clearly lies between steel and wrought-iron. I say this with no disparagement of Major Palliser's system of adapting cast-iron smooth-bore guns for rifling, by introducing a tube of coiled wrought-iron, but this method has, hitherto, only been applied with success to guns which, though formerly classified as heavy ordnance, are dwarfed by comparison with the ponderous guns of the present day.

For these we require the greatest strength we can attain, and cast-iron cannot possibly be regarded as so efficient for enveloping the internal tube as either wrought-iron or steel. In discussing which of these two materials is best, I shall be trespassing on controversial ground. Krupp and Whitworth, both great names in gunnery, though differing widely in their views on other points, agree in this, that steel is the right material for the entire gun. I, on the other hand, have always advocated wrought-iron in the form of welded coil for the chief mass of the gun, limiting the use of steel to the internal tube, which has abrasion to resist as well as tensile strain. The expression of my opinion upon this point may probably not be considered impartial, but I will nevertheless state the grounds upon which my preference of wrought-iron thus applied is based. It has been found both in Elswick and Woolwich guns, that whenever failure takes place, it almost invariably originates with that part which is made of steel. It is the steel tube which is nearly always the first to crack. So, also, when the vent-pieces or closing blocks of the breech-loading guns were made of steel, their fracture was alarmingly frequent, but since wrought-iron has been substituted, such occurrences are rare. The conclusion, therefore, at which I long since arrived, and which I still maintain, is that, although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain.

This conclusion is in strict harmony with the fact that armor-plates made of steel have proved on every occasion of their trial, greatly inferior to plates of wrought-iron. The experiments which I made some years ago on the toughening of steel in large masses, by immersion, when heated, in oil, led me to expect that this fragility would be obviated by that process, and I felt sanguine that I should be able by such treatment to produce steel armor-plates of extraordinary resisting power. An armor-plate of steel was accordingly manufactured for experiment, and was tempered in a large bath of oil. Its quality was tried by test pieces cut off after tempering, and proved by tension and bending. The results showed a very high tensile strength, combined with so much toughness, that I was unable to match its bending power by any sample of iron I could compare with it. The plate was then sent to Portsmouth for trial, in the fullest confidence of its success, but two shots from a 68-pounder sufficed to break it in various directions, and it was justly pronounced a failure.

With these experiences before me, it is impossible that I can hold any other opinion than that the vibratory action attending excessive concussion is more dangerous to steel than iron, and were it not necessary to provide a harder and more homogeneous substance than wrought-iron for the surface of the bore, I should entirely discard the use of steel for the manufacture of ordnance. I do not mean to contend that very strong guns may not be made of steel, but I am convinced that failures will be more frequent, and, I may add, more disastrous, with steel than with iron, when the conditions of trial are the same. The want of uniformity in the quality of steel, continues to be another serious objection to its use; and, in addition to all these considerations, the element of cost is greatly in favor of the wrought-iron coil construction over every mode of manufacture in steel.

I will now offer a few remarks upon the interesting question of the probable future of guns. Upon the solution of this question depends the pattern of future ships, and also the policy of continuing or abandoning the struggle of armor-plates against guns. From my previous remarks on the increase of pressure with which we have had to contend as we have increased the size of our guns, it might be inferred that we were now nearly reaching a limit, beyond which the strength and endurance of our material would not enable us to pass. I am not prepared to say how far we could have advanced under the recently existing conditions; but certainly every increase of size would have been attended with increase of difficulty.

A new light, however, has just dawned upon the subject, which entirely alters the prospect. It has become apparent that the power which we have been using can be so modified as to produce the required effect, with greatly less strain upon the gun. It may appear paradoxical that there should be a limit to the theoretical advantage of increasing the initial pressure of the gas evolved in the gun, but the apparent anomaly will disappear on examination. The action of expanding gas in a gun is analogous to that of expanding steam in the cylinder of a steam engine, and we all know the advantage, in the case of steam, of having a high pressure to begin with, provided a steam jacket be used to maintain

the material of the cylinder at a temperature equal to that of the entering steam. But in a gun we can have no provision analogous to the steam jacket, and it would appear that it is owing to the necessary absence of such a provision that there is a limit to the increase of initial pressure, beyond which no gain of propelling force is realized.

Perhaps I shall not be fully understood without explaining this curious and important subject in a more definite manner, and I will therefore endeavor to do so. The force exerted in a gun bears a certain relation to the heat evolved by the gasification of the charge. The greater the heat the greater the force, for heat is nothing more than unexpended force. I have already alluded to the loss of heat by transmission to the gun, and it is evident that this transmission must be greatest in amount when the heat of the gas is highest. By using a slower burning powder, less heat and pressure are evolved at first, and the waste of heat in the stage of initial pressure being less, more heat remains for expansive action. Hence the slower burning powder is weaker at first, but stronger afterwards, and although the total quantity of gas be only the same, and the pressure not so great at any point, yet the aggregate pressure throughout the bore may equal that of the more energetic and more dangerous powder. This would not be so if the gun, like the steam-jacketed cylinder, could be maintained at the maximum temperature of the elastic medium within. But in the case of the gun, that temperature would be far above the melting point of its own material.

It is only lately that attention has been strongly directed to the powder question in England. In Russia and Prussia, where great efforts have been made to obtain endurance with large rifled guns, powder similar in granulated form to that used in England, has long been wholly discarded and superseded by powder stamped into prismatic blocks, which burn more slowly; but although we have erred in using a powder for our new ordnance, so violent as to be justly designated "brutal," by the French, yet we have this satisfaction, that the ordeal which our guns have sustained with our severer powder, affords an assurance of strength which we could not have had if they had only withstood the mild description of powder with which alone continental guns have been successfully tried. Attention is now fully awakened to the subject, and a scientific military committee is conducting experiments upon the force of different descriptions of powder.

In these experiments the pressures exerted in every part of the gun are determined, by the use of an instrument of exquisite delicacy, invented by my friend and partner, Captain Noble. This instrument, which is a happy combination of mechanical and electrical action, indicates the velocity attained by the projectile at any number of points in the gun, and from these velocities the pressures are deduced by calculation. Thus a diagram of pressure can now be exhibited for gas in a gun, as well as for steam in a cylinder, and I think you will agree with me in regarding this result as no small triumph of mechanical science. The mitigation of initial pressure, which is now known to be compatible with the maintenance of efficiency, opens a new future for guns, and removes all doubt as to the practicability of increasing their size and power to an extent which it would be vain to follow on the side of the defense by increase in the thickness of armor.

No present armor-clad vessel is proof against present guns, and there is not the slightest probability that future armor will be proof against future guns. Ships of the Warrior class can already be pierced with shot or shell, fixed at considerable ranges, by even second-class guns, and the still stronger ships, now in course of construction, are pretty sure to be similarly overtaken in a very few years. Unless armor be invulnerable, it is of very doubtful advantage as a defense. It will, perhaps, prevent the entrance of shells, containing large bursting charges, but on the other hand the passage of a shot through the thick side of an armor-clad, carries with it a mass of fragments that would act with terrible effect upon the crew. If we cannot stop a shot, the next best thing is to facilitate its passage through.

Wooden ships are out of the question, because they are combustible, but we may have ships of iron without the armor. Whatever weight we carry as armor, we lose as armament, and if we lessen the offensive power of a ship, by loading her with armor, we ought to be very sure that the armor will realize its defensive purpose.

The efficiency of modern ordnance against armor-plate is dependent, not only on the power of the gun, but also upon the material and form of the projectile. Ordinary

cast iron proved absolutely useless for projectiles to be used against thick armor-plates, and until Major Palliser applied the process of chilling to the manufacture of cast-iron projectiles, there was every reason to believe that hardened steel was the only material that could be used for this purpose with effect. The process of chilling gives extreme hardness to cast-iron, but, in point of toughness, a chilled cast-iron shot is inferior to one of steel. Steel, however, though much less liable to break, is more easily crushed; and this brings me to notice a curious evidence of difference in the amount of the penetrative power lost by crushing and by breaking. A crushed projectile is always much less heated by the blow, but the fragments of a chilled projectile remain cool. Hence, we see that crushing detracts more from the power of a projectile than breaking, because the heat developed in a projectile by striking a plate, is a criterion of the amount of force expended upon the projectile, instead of the plate. We accordingly find that a Palliser shot breaking by impact, will nevertheless pierce more easily than a steel shot which remains whole, but yields to crushing.

As to the proper form of head to be given to the projectile for piercing armor, you will remember that a few years ago this question was hotly contested between the supporters of round heads and flat heads; but, as often happens in the case of human contentions, not limited to the sphere of mechanical engineering, both parties were afterwards proved to be wrong. When Major Palliser brought forward his chilled projectile, he advocated a pointed head, and with the new material he was found to be right. Major Palliser has competitors on the Continent, whose claims I cannot pretend to weigh, but in this country, at all events, he is entitled to the honor of improving both the material and the form of the projectile, thereby greatly increasing the penetrative power of our artillery, and, at the same time, effecting an enormous economy in the manufacture of projectiles.

The most legitimate use of instruments of war is for the purpose of home defense, and I, therefore, proceed with satisfaction to notice a class of inexpensive vessels requiring no armor, and adapted to render the heaviest artillery available for the protection of our shores and harbors. Until very recently, there seems to have been an impression that large guns required large vessels to carry them; but the fallacy of this idea has been practically shown by the proving barge of the Elswick works, which is a mere floating gun carriage. This little vessel, which is only sixty tons burden, is continually used, without difficulty, for the trial of twelve ton guns at sea, even when the swell is considerable. This proving barge was the origin of Mr. Rendell's idea of the now well known gunboat Staunch.* The Elswick barge has no steam power, and thus represents the minimum of size; but the Staunch is provided with steam power, both for propulsion by means of twin screws, and for working her twelve-ton gun. She is, therefore, somewhat larger than the Elswick barge, and yet so small as to be very inexpensive, and at the same time a very difficult mark to hit. To burden such a vessel with armor, would at once increase her size and her cost, thus rendering her more easy to hit, and more expensive to lose. A simple screen might, perhaps, be advantageously applied as a protection against shrapnel; but thick armor, if used at all, should be reserved for ocean ships. I have so recently published my views on the subject of this vessel, that I need not now repeat them further, merely observing that guns of the largest size now made, or ever likely to be made, may be mounted in vessels similar to the Staunch, without increasing their tonnage in more than a proportionate degree.

Another recent invention, highly favorable to defense, is the celebrated gun carriage of Captain Moncrieff. By the ingenious arrangement of the carriage, the recoil of the gun operates in a downward direction, and in descending it lifts a counterweight, which, when liberated, after loading, raises the gun again to the height necessary for firing over the edge of a parapet. By this mechanism, the gun is handled with almost perfect security to the men, and is itself exposed in the smallest possible degree, and only for a few seconds while being fired. No embrasures being required, the gun is not rescricted in lateral range. This is the characteristic advantage of the barbette system of mounting guns, which has, however, the fatal objection of exposing both guns and gunners. Embrasures are always a source of trouble in fortifications. They not only

* The idea of floating, self-propelling gun carriages, was original with the late Edwin A. Stevens, one of the projectors of the "Stevens Battery," and the first practice in this direction was that of the Stevens gun boat "Naugatuck," during the late war.—Ed.

admit but guide projectiles into the fort at the very points where guns are placed. In iron defenses, the opening for the gun is even more objectionable. Not only does it weaken the whole structure, but it serves to break up cast-iron shot striking on the edge, and thus to occasion terrible destruction inside. I may state as a fact, communicated to me by a Brazilian officer, on whose testimony I rely implicitly, that in the late Paraguayan war, in which he was engaged, he saw whole gun crews swept away in the Brazilian iron-clads, by common cast-iron round shot, contemptible for piercing even the weakest armor, but which, striking the edge of the port, entered the ship in a torrent of fragments. The Moncrieff gun carriage gives great additional value to earthworks, and, in fact, may be used in mere pits which would be wholly invisible to an enemy. It would probably also prove to be available in combination with iron defenses, as a means of avoiding the objection of port-holes, and it will have the effect of placing muzzle-loading guns on a par with breech-loaders in regard to security and ease of loading. Captain Moncrieff's invention will play a very important part in defensive operations, and will greatly reduce the expense of fortifications.

Many other instances may be cited in illustration of the tendency of mechanical progress to favor defense. Thus the increasing size of guns renders them difficult to transport for offensive use abroad, but creates no impediment to their defensive application at home. Or, if we look to the nautical side of the subject, we see that the conditions sought to be attained in war-ships for aggressive action involve enormous cost, and that the great size of these vessels makes them favorable targets for the fire of opposing artillery. On the other hand, the vessels required for coast and harbor defense are of cheap construction, and their small size and facility of movement give them the advantage of being difficult to hit. The Moncrieff carriage is applicable almost exclusively to defensive purposes; and the same may be said of torpedoes, which, by many ingenious contrivances, have recently been rendered most formidable obstacles to naval attacks upon seaports. The tendency, therefore, of mechanical invention, as applied to war, is to discourage aggression, and thus to maintain peace. We may, consequently, hope that it will hasten the arrival of a period when civilized nations will abandon the arbitrament of arms, and settle their differences by rational and peaceable methods. But, while I defend the mechanical branch of military science from all imputation of serving the cause of war, I do not forget that it is to the civil branch of mechanical engineering that the honor of promoting the friendship of nations especially belongs. It is by the facilities it gives to intercourse and exchange, and by the reciprocal benefits which flow therefrom, that it teaches men how much they have to gain by peace and lose by war.

THE AVONDALE DISASTER.—We have in this country long been spared the frequent and ghastly disasters that characterize British mining. Even the few catastrophies that have occurred here, are attributable to carelessness and neglect rather than to the presence of noxious and inflammable gases. It would appear that human ingenuity could hardly have devised a more certain man-trap than the Avondale mine. But whatever the causes of these terrible sacrifices may be, *mining by machinery* will now begin to have the significance and attention here that it is receiving abroad. The breaking down, moving and manipulating of coal by inanimate power, with only the supervision of a few men, will at once and greatly decrease the risks to human life and the cost of getting coal—and humanity has little to hope for if economy and safety do not go hand in hand.

THE ELLERSHAUSEN PROCESS.

We publish, herewith, a table of the results of several single heats made by this process at the Bessemer Steel Works, Troy, and also the results of five weeks' continuous working at the establishment of Messrs. Shoenberger & Co., at Pittsburg.

The mixing of the ore with the melted pig-iron, in the Troy experiment, was thorough, and the subsequent operations in the puddling furnace were very carefully performed. The results, however, are not uniform, and do not, as a rule, show the improvement in the quality of the product observed elsewhere. It is now evident that the Troy experiments were not sufficiently extended to give a fair average result. It appears from these experiments that some irons are better adapted to this process than others; also that the ore from which the pig-iron is made is not the best ore to mix with the same pig-iron, to convert it into a pig-bloom.

Experiments made by the Ellershausen Process, at the Bessemer Steel Works and at the Rensselaer Iron Works, Troy, N. Y., April, 1869.

Kind of Pig.	Kind of Ore.	Percentage of ore to 100 lbs. pig. Ellershausen.	Weight charged in furnace.	Yield.	Loss in lbs.	Per cent of loss of product. Ellershausen.	Per cent of loss of product in ordinary puddling.	Per cent of ore used in fettling Ellershausen.	Per cent of fine ore on yield. Ellershausen.	Total per cent on product of ore used. Ellershausen.	Total per cent on product of ore in ordinary puddling.	Average time per heat Ellershausen.
												h. m.
Fort Edward No. 3	No. 21 Port Henry	21.9	4,615	3,710	905	19.61	.....	45	30.98	75.98	45	1 30
do	No. 21 do	33.	4,875	3,610	1,265	25.95	.....	45	44.56	89.56	.....	1 30
do	No. 21 do	25.1	4,760	3,910	850	19 95	.....	45	30.56	75.56	.....	1 30
Clove No. 1. I	No. 21 do	24.9	4,740	3,360	1,380	29.11	5.30	90	35.42	125.42	60	2 30
do No. 1. II	Dakin hematite	14.3	4,765	3,555	1,210	25.40	.....	90	19.17	109.17	.....	2 30
do No. 1. III	No. 21 Port Henry	30.7	4,585	3,220	1,365	29.77	.....	90	43.71	133.71	.....	2 30
R. I. W. Mixture, ½ Hudson No. 2, ½ Fort Edward No. 3.	No. 21 do	32.5	5,123	3,880	1,243	24.26	2.22	45	42.91	87.91	45	1 30
R. I. W. Mixture	No. 21 P. H., 90 per ct. Oxide manganese 10 pr cent	22.4	4,995	3,845	1,150	23.02	.....	45	28.82	73.82	.....	1 30
Puddled by Ordinary Process.												
Clove No. 1	.....	.....	1,320	1,250	70	5.30	5.30	60	.....	.....	60	
Fort Edward No. 3	.....	.....	2,700	2,730	gain 30	.....	.....	45	.....	.....	45	
R. I. W. Mixture	.....	.....	2,700	2,670	loss 30	.....	2.22	45	.....	.....	45	

Experiments made by the Ellershausen Process, etc.—Continued.

Kind of Pig.	Kind of Ore.	Average time per heat puddling.	Reheated.				Appearance of Fracture of Bars made by cutting up puddle-bars and re-heating them once.
			Charged, lbs.	Yield, lbs.	Loss, lbs.	Per cent of loss.	
		h m.					
Fort Edward No. 3	No. 21 Port Henry	.....	760	710	50	6.58	Fracture nearly all granular and rather cold short; not red short
do	No. 21 do	.....	750	685	65	8.67	Fracture granular and cold short; not red short.
do	No. 21 do	.....	790	750	40	5.06	Fracture granular and quite cold short; not red short.
Clove No. 1. I	No. 21 do	.....	745	700	45	6.04	Fiber close and silky; very tough; very slightly red short.
do No. 1. II	Dakin hematite	.....	760	700	60	7.90	Granular and fibrous streaks; rather cold short, but not red short.
do No. 1. III	No. 21 Port Henry	.....	735	675	60	8.16	Granular and fibrous streaks; rather cold short, but not red short.
R. I. W. Mixture, ½ Hudson No. 2, ½ Fort Edward No. 3.	No. 21 do	.....	.....	.....	.....	.....	Fibrous and silky fracture; very tough; much better than the same puddled; not red short.
R. I. W. Mixture	No. 21 P. H., 90 per cent. Oxide manganese 10 per cent	.....	.....	.....	.....	.....	Fiber more close and silky than the above; very fine and tough; not red short.
Puddled by Ordinary Process.							
Clove No. 1	.....	1 30	690	635	55	7.97	Entirely fibrous and silky; neither cold short nor red short.
Fort Edward No. 3	.....	1 20	730	670	60	8.22	Fracture partly granular; fibrous part quite silky; slightly cold short; not red short.
R. I. W. Mixture	.....	1 20	755	700	55	7.28	Granulated with streaks of fiber; cold short; a little red short.

Analyses of some of the Materials and Products in the Troy Experiment.

	Clove pig.	Clove puddle bar.	Cove III, Ellersh'n bar.
Total carbon	3.75	1.158	.34
Combined silicon...	4.15	.298	.026
Phosphorus.....	.38	.273	.29
Sulphur	.09	none.	.0034

	Fort Edward No. 3, pig.	Fort Edward puddle bar.	Fort Edward Ellers. bar.
Total carbon.....	4.17	.38	.197
Combined silicon...	1.54	.04	.261
Phosphorus	.93	.28	.480
Sulphur	.016	.0096	none.

Dakin Hematite Ore.

Sesquioxide of iron.....	62.94
Protoxide of manganese	.40
Silica.	26.32
Water	10.65

Port Henry No. 21 Ore—Magnetite.

Sesquioxide of iron	60.39
Protoxide of iron	27.06
Titanic acid	1.30
Silicic acid	5.38
Magnesia	2.36
Alumina	2.80

The results of five weeks' working at Messrs. Shoenberger & Co.'s, are based on the amount of ore used in the blast-furnace, also the amount of pig metal and of pig-bloom (conglomorate of ore and partially decarburized pig-iron, as obtained by the Ellershausen process), and the average loss on the pig bloom.

During this time all the cinder from the Ellershausen process was used in another blast-furnace where they were making white iron for a rail mill in Chicago.

Ore used.		lbs.
Mannora	at 50 per cent,	2,286,502
Iron Mountain	at 66 "	1,299,789
Sterling	at 50 "	613,307
Lake Superior	at 62 "	498,882
Containing iron.....		2.617,540

Iron produced.	lbs.
Pig metal.....	739,200
Pig bloom	2,452,800
	3,192,000

Loss on pig bloom in furnace 24 per cent (average), the bloom containing, according to the calculation of Messrs. Shoenberger & Co., about 27 per cent of ore (Lake Champlain).

Supposing even that the pig metal, if worked into the Ellershausen bloom, had yielded only its own weight in muck-bar, instead of gaining 3 per cent, then we have

	lbs.
Iron from pig metal.....	739,200
" pig bloom	1,849,600
Total amount of iron...	2,588,800

This would show only a loss of a little above one per cent over the amount of iron contained in the ore as found by analyses.

The loss in puddling their pig, Messrs. Shoenberger have found to average 8 per cent.

It is a fact that Messrs. Shoenberger & Co. have not heretofore been able to make horse-shoes from their own puddled iron, but were always compelled to buy good scrap iron. Now they are making all their horse-shoes from the Ellershausen iron, the *horse-shoe billet* being rolled directly from the muck-bar.

The following data relating to the Ellershausen process are from Messrs. Shoenberger & Co.'s books:

In *the puddling process* the production of a single puddling furnace is about 2,600 lbs. per day.

To fix the bed of furnace takes from 100 to 150 lbs. of scrap iron.

To fix the bed of furnace takes from 200 lbs. of ore.

In the *Ellershausen process* the production per day, in single furnace, is 4,000 lbs.

To fix the furnace-bed they have used only 50 lbs. of ore per day, and *no scrap.*

Working in a large furnace—three men to the furnace—the yield per shift has been for months 6,300 lbs., consuming only 70 bushels of bituminous coal, while in puddling they use 47 bushels of coal per ton of muck-bar.

Table of Analyses.

1. Pig metal from Messrs. Shoenberger & Co., gray.
2. Pig metal from Messrs. Shoenberger & Co., white (only with reference to sulphur—was made from ore containing considerable am't of pyrites.
3. Slag from puddling process.
4. Slag from Ellershausen process.
5. Muck-bar puddled iron.
6. Muck-bar Ellershausen iron.
7. Muck-bar puddled iron.
8. Muck-bar Ellershausen iron.

	1.	2.	3.	4.	5.	6.	7.	8.
Carbon chem. comb.	2.87	....	....	....	.43	.39		
Graphite	1.34	....	....	....				
Silicium	1.02	....	....	....	.20	.09		
Sulphur	.14	.42	....	....	.011	.006	.027	.012
Phosphorus	.58	....	....	....	.12	.14		
Iron	92.46							
Silicic acid	....	....	14.02	8.95				
Peroxide of iron	....	....	17.71	16.01				
Protoxide of iron	....	....	60.31	68.88				
Lime	....	....	2.08	1.74				
Magnesia	....	....	.84	.85				
Alumina	....	....	1.44	1.31				
Phosphoric acid	....	....	2.54	1.74				
Sulphuret of iron	....	....	.88	.72				

Copper, cobalt, aluminum, calcium and slag not determined.

Analysis of Pig Metal and Muck-bar for Messrs. Shoenberger & Co.

a. Pig metal from Sligo furnace (gray).
b. Pig metal from Sligo furnace (white).
c. Pig metal from Penn. furnace (gray).
d. Pig metal from Penn. furnace (white).
e. Muck-bar from Sligo iron, puddled.
f. Muck-bar from Sligo iron, Ellershausen process.
g. Muck-bar from Penn. furnace, puddled.
h. Muck-bar from Penn. furnace, Ellershausen process.

	a.	*b*.	*c*.	*d*.
Iron	93.01	93.40	94.45	
Manganese	.21	.41	trace.	
Silicium	.93	.28	.41	.31
Phosphorus	.59	.65	.22	.19
Sulphur	.03	.03	.009	trace.
Carbon combined	1.05	4.81	1.34	4.74
Graphite	3.86	.21	3.18	.24
Slag	.34	.21	.40	.31

	e.	*f*.	*g*.	*h*.
Carbon	.34	.29	.31	.24
Silicium	.17	.16	.07	.05
Phosphorus	.25	.22	.16	.15
Sulphur	trace.	....	none.	none.

The ore used for mixing in the Ellershausen process was a brown hematite, containing .21 phosphoric acid, 63.00 peroxide of iron, 13.00 water, balance almost exclusively silica and alumina.

In the iron of Lyon, Shorb & Co., from cold blast charcoal iron, there is no perceptible difference between the puddled and the Ellershausen iron, as far as the analysis goes. Mr. William M. Lyon considers the Ellershausen iron supperior to the puddled iron when brought to practical test.

In the experiments of Messrs. Shoenberger & Co., it has been shown that the sulphur is far more thoroughly eliminated by the Ellershausen than by the puddling process.

We shall give, in a future number, the results of the Ellershausen process as tried on a still larger scale, during several months regular working.

PILE-DRIVING BY GUNPOWDER.

From "Engineering."

Considerable attention has lately been paid in America to the ingenious method of driving piles by the explosion of gunpowder recently introduced by Mr. Thomas Shaw, of Philadelphia, and we think that Mr. Shaw's system is likely to be regarded with equal interest on this side of the Atlantic. Mr. Shaw's "gunpowder pile-driver" as it has been named, consists merely of an ordinary pile-driving engine, having a ram provided with two plungers projecting, the one from its upper, and the other from its lower end, and fitted, moreover, with an arrangement for retaining the ram at any desired height. On the top of the pile to be driven is placed a casting, or cylinder, hollowed on the under side to fit the head of the pile, and having bored from its upper side a hole, into which the lower plunger of the ram fits. In this hole is placed a small charge of gunpowder, and the ram, having been raised a few feet, is let fall, when the lower plunger, entering the hole in the cap-piece, compresses and heats the air, which ignites the powder, thus causing the ram to be thrown up again, ready for another blow, and the cap-piece with the pile to be forced downwards.

The plunger at the top of the ram is for the purpose of entering into an air cylinder at the top of the frame, and thus forming an air buffer in the event of the ram being thrown up too high. This upper air cylinder is also useful when there is but little space available for striking a blow, as, in such cases, by hauling up the ram until the upper plunger is forced into the air cylinder, the downward stroke of the ram is accelerated.

So far the action of the apparatus is simple enough, and will be readily understood; but the results obtained with it are difficult to account for satisfactorily. Inasmuch as in regular working the ram is thrown up again to its starting point, it is evident that any work given out by it during its downward stroke must be re-absorbed by it during its upward stroke, and, therefore, that none of the work generated by the fall of the ram can be considered to be available for driving the pile. This driving action must therefore be performed by the power generated by the explosion of the powder, and it is the amount of effective work thus done by the powder which appears to us to be the most remarkable point in the whole affair. Thus, in the case of a model apparatus, lately exhibited by Mr. Shaw at a meeting of the Franklin Institute, the ram, with its plungers, weighed 73 lbs., and had a fall of 20 ft. When no powder was used, a pile, placed under this ram, was driven $\frac{1}{4}$ in. at each blow; but when a charge of 14 grains of white gunpowder (composed of chlorate of potash, ferrocyanide of potassium, and sugar) was employed, the distance which the pile was driven at each stroke was augmented to 2 in., or eight times its former amount. Now, if in this case we were to consider the power expended upon the pile to be in proportion to the distance which the latter is driven, we shall have the explosion of 14 grains of powder generating $73 \times 20 \times 8 = 11{,}680$ foot-pounds of work, or, as 14 grains are equal to $\frac{1}{500}$ lbs., there would be $11{,}680 \times 500 = 5{,}840{,}000$ ft.-lbs. of work developed by the explosion of 1 lb. of powder! Inasmuch, however, as a pound of ordinary powder, burnt in a gun, only developes, on an average, about 180,000 foot-pounds of work, we cannot think—even allowing for the white gunpowder being more powerful than the ordinary kind—that the power developed by the explosion of the powder in Mr. Shaw's pile-driver is anything like that above mentioned; and we are, therefore, led to believe that the efficiency of the apparatus lies more in the peculiar character of the thrust transferred to the pile than to any vast amount of power generated. In other words, it appears to us that in the gunpowder pile-driver a greater proportion of the driving power is turned to useful account than when the ordinary falling monkey is used, and this view of the case is borne out by the fact that with Mr. Shaw's apparatus no injury is done to the head of the pile itself. In the case we have just been considering, the ram was a light one, and its fall great, and these circumstances may at first sight appear to have contributed to the great comparative success of the apparatus when used with powder; but a reference to the report of Mr. Shaw's pile-driver, recently made by Chief-Engineer W. W. W. Wood, U. S. N., will show that, even with a heavy ram and short stroke, the advantages gained by the use of the gunpowder were equally great.

That Mr. Shaw's apparatus forms a very efficient pile-driving engine, Capt. Wood's report, and other information which we have received from reliable private sources, leave us no reason to doubt; whether, however, it is an economical one we have as yet not sufficient data to enable us to determine. In Captain Wood's report, the quantity of powder used is unfortunately not given, neither does the report afford any information concerning the number of men required to work the machine when in regular action. It must be remembered that in a well-arranged steam pile-driver the engine not only serves for working the ram, but also for lifting the piles into place, traversing the machine as required, and doing other work which, if it is to be done economically, must be performed by steam power in the case of Mr. Shaw's pile-driver also; and the question then arises whether, if an engine and boiler have to be provided, it is not better to employ them for doing all the work that has to be done. As regards the comparative cost of developing power by the combustion of coal under a steam boiler, and by the explosion of gunpowder, there can be little difference of opinion, as a pound of coal burnt under the boiler of a steam pile-driver will, on an average, allowing for all losses, produce about the same number of foot-pounds of effective work as a pound of ordinary gunpowder burnt in the chamber of a piece of ordnance, while the cost of the coal will in most cases only be

about one-fiftieth of that of the powder. Even supposing the powder to have the vastly increased efficiency estimated from the experiments at the Franklin Institute above mentioned, the cost of generating a certain number of foot-pounds of work would still be in favor of the coal, and it remains to be proved whether in actual working Mr. Shaw's apparatus gives, from its handiness and rapidity of action, results which compensate for this increased cost of generating the power.

Whether Mr. Shaw's gunpowder pile-driver will be able to compete successfully with steam pile-drivers or not, it will undoubtedly render important services in situations where hand-worked machines have hitherto only been available; and in any case its action is in many respects so peculiar, that we feel sure that its further trials will be watched with interest by all who have had their attention directed to this subject.

ICE-MACHINES AND REFRIGERATORS.

From "The Engineering & Mining Journal."

For a century or more the great problem of converting heat into power was being solved, or, in other words, the steam-engine was being brought into existence. It advanced through various stages, and appears now to have attained, perhaps if not its full growth, at least a very high degree of development. At present another problem is being solved—namely, to convert power into cold; in other words, to construct machines to make ice, or produce cooling by means of the application of power; and as the cheapest power we possess is steam power, this is almost exclusively used, when we have the problem to produce cold by mechanical means.

The production of heat by mechanical means is very ancient. From time immemorial, the friction of two rubbing surfaces, such as a grooved board and a stick, has been used by savage races to produce fire; and the heating of the axle-trees of wagons and machinery by friction was observed centuries ago. Comparatively speaking, the practice and successful application of these phenomena have been carried out only recently. In a few factories in Germany, where there was a surplus of water-power, an arrangement was made for producing friction between two cast-iron surfaces, which became heated to such a degree that enough caloric was produced to perform the function of a heating apparatus for various rooms; while Beaumont, in 1856, constructed a heating arrangement driven by power, where the heat was produced by the friction of a very elongated cone of soft meterial, well oiled, and which was placed in a hollow metallic cone,* in which it fitted exactly. Upon being rapidly revolved, a perfectly noiseless friction was the result, producing the full equivalent of heat, as determined by Meyer, Joule, Grove, etc., and to which we have often referred before, namely: one unit of heat for every 772 foot-pounds power employed. The specific heat of one pound of water, being nearly equal to that of 50 cubic feet of air, every 772 foot-pounds will heat 50 cubic feet of air 1 deg., and 120×772, or 92,600 foot-pounds, will heat 120×50, or 6,000 cubic feet of air, 1 deg. If we spend this power every minute, we will have nearly 3-horse-power, as each horse-power is 33,000 foot-pounds per minute. Three horse-power properly employed will therefore heat a space of 6,000 cubic feet (the contents of a common passenger railroad-car) 1 deg. every minute. But as three-horse power cannot be obtained from a locomotive, by a consumption of coal of less than 30 lbs. per hour, it is seen at once that it would not be an economic operation, as so slight a calorific effect may be easily obtained from a common stove, with a consumption of less than one-tenth the above, two to three pounds of coal per hour; which is the average amount burnt in a stove of moderate size, and heats a room of the above dimensions sufficiently, even in the coldest season.

One of the most remarkable facts in connection with the transformation of power into heat, is the perfect uniformity of result, whatever be the means employed to accomplish this transformation. It may be friction of solids, of solids on liquids or gases, through agitating them by means of fan-wheels or other means, compression of gases, magnetic attractions, or by retarding revolving wheels. In short, there may be any means whatever employed to retard or destroy power or motion, we will always have the uniform result; that for every 772 foot-pounds apparently destroyed, one unit of heat will have been obtained—the only condition being precaution not to lose part of the heat thus obtained, nor to consume part

* For description of this apparatus, see *Génie Industriel*, Paris, 1856, page 18.

of the power employed in some other manner. By observing these conditions, different experimenters, employing a variety of means, have obtained such uniform results, that the number obtained, 772, representing the equivalent of heat and power, is one of the most securely established in the whole field of physical sciences.

When converting heat into power, by means of the steam-engine, the results are quite different, and the most enormous discrepancies appear, one machine producing nearly 110 foot-pounds per unit of heat, another 70, another 50, and another only 35 or 40—these numbers being respectively about 1-7th, 10th, 15th, and 20th of 772. It is thus seen that steam-engines produce only small portions of the theoretical amount, and are subject to a loss, ranging from 86 to 95 per cent of what we are some day entitled to expect.*

Referring to the subject mentioned in the opening of this article, the conversion of power into cold, the following question naturally presents itself: Is this conversion practically accomplished without great loss, and with tolerably uniform results, as in the case of the conversion of power into heat? Or is it subjected to the great loss of 86 to 95 per cent, as is the case where heat is converted into power by the intervention of the steam-engine? In answer to this question, we will state that in this case there is fortunately no such loss; when converting power into negative heat, we are able to abstract with a good ice-machine a unit of heat for every 772 foot-pounds of power employed; or 170 units for 170×772, or nearly 132,000 foot-pounds. If we expend the last number of foot-pounds per minute, we spend four-horse powers, and therefore theoretically four-horse power must produce a cooling effect of 170 units of heat per minute. As one pound of water of 62 degrees requires 30 degrees cooling to bring it to 32 degrees, and the abstraction of 140 units of latent heat, 170 units of heat abstracted from one pound of water at 62 degress will change it into ice of 32 degrees; and thus an expenditure of four-horse power must be able to freeze every minute one pound of water of 62 degrees—that is, sixty pounds per hour; and 40-horse power will freeze 600 pounds per hour, or 6,000 pounds per day of ten working hours.

This estimate, which gives the maximum amount of ice which can be produced by a given power, shows at the same time that the reason why artificially obtained ice can compete with natural ice, is, that steam power is so cheap. It has been suggested to make small machines, in which, by the labor of a man, ice, or at least cooling, could be produced, and such machines have actually been made, but only with doubtful success. This becomes clear when we consider that one-man power being only the 32d part of four-horse power, one man could freeze only the 32d part of a pound of water, one-half ounce per minute, or one pound in 32 minutes; this would be the maximum attainable, and that by hard labor, the most perfect arrangement, precaution against loss of power, absorption of heat, etc., all more difficult to obtain on a small than on a large scale. We are compelled to come to the conclusion that the system of refrigeration by means of power is only applicable on a large scale where steam or water power is available. To use the labor of a man to produce cooling by this system, is more expensive, as would be that of animals, in comparison to the employment of steam or water power.

If we estimate the amount of coal necessary to produce the result calculated above—namely, the production of 6,000 lbs. of ice per day by a steam-engine of 40-horse power—we find that, as a horse-power requires in an economical stationary boiler and engine 20 pounds of coal per hour, the 40-horse power will consume per day of 10 working hours 800 pounds of coal. The consumption of this 800 pounds of coal producing 6,000 pounds of ice, gives $7\frac{1}{2}$ pounds of ice for every pound of coal, or $7\frac{1}{2}$ tons of ice for every ton of coal on the supposition that each horse-power consumes two pounds of coal per hour. As, however, in the most economical boilers, a horse-power may be produced by the consumption of less coal, it is clear that it becomes possible to obtain more ice per ton of coal, which quantity can be further increased by future improvements in the steam-engine.

Having thus estimated what we may expect theoretically, let us investigate in how far the practical results obtained agree with these estimates.

In the first ice-machines, built on this principle, some ten years ago, one or two tons of ice were obtained by the use of one ton of coal, and it was at that time considered a great attainment that actually more ice was

* Readers desirous for details in this matter, are referred to the "Journal of Mining" for 1869.

turned out than coal consumed. Very soon it was claimed that, by means of the *ether-machine*, three tons of ice were daily produced by the consumption of seven tons of coal per week; then the ammonia-machine made four to six tons of ice for every ton of coal, which production was gradually increased to eight and ten tons, while lately twelve tons have been claimed for every ton of coal consumed. An ice-machine made by Liebe, and used in England for cooling purposes in a large brewery, produced a cooling effect, which formerly, by means of ice, could only be obtained by the consumption of 14 tons of that bulky material, while the ice-machine of Dr. Vander Weyde, of this city, which is now being introduced in the United States, is, it is claimed, more economical, and will in its effect excel Liebe's when perfected and worked with superior boilers and engines.

In regard to the cost of the ice thus produced, which is the chief consideration, we may say, it consists of the first outlay, the fuel and the labor. Considering the outlay, an ice-machine with a steam-engine of 40-horse power and boiler, costs, say $5,000, interest of capital, wear and tear of machine, at 15 per cent, $15 per week; labor $18, coal $7, water nothing; total, $40 for 20 tons of ice, or $2 per ton, slightly less or more, according to economy and price of coal and labor.

It is very fortunate that ice-making or conversion of power into cold, is not subject to from 86 to 95 per cent of loss, which is the case, in the conversion of heat into power, in the steam-engine. If this was the case, the tenth or twentieth part only, of ice could be made, with the same amount of machinery, fuel and labor, as now, and the price would be at least $20 to $40 per ton, in place of $2. It is clear that in this case artificial ice could seldom compete with natural ice, which for that price could even be conveyed to the tropics. However inland in tropical climes, it commands often $100 and more per ton, if it is to be had at all, and in such exceptional circumstances, even very expensive methods of cooling may be taken advantage of.

FAGGOTED AXLES.—The Albany Iron Works are making hammered iron railroad axles of a very superior quality. We shall in due time give the particulars of some tests of these axles, under the blows of a drop.

POPPER'S ANTI-INCRUSTATOR FOR STEAM-BOILERS.

By Dr. EMIL TEIRICH.

Translated from "Polytechnic Journal."

The incrustation of steam-boilers prevents, to a great extent, the transmission of the heat, and causes an early destruction of the boilers. Its removal from time to time is very expensive and inconvenient. The nature and quantity of this incrustation depends on the chemical composition of the feed-water.

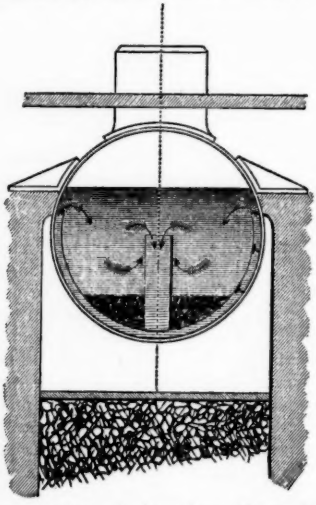
When the water is first heated up to the boiling point, the bicarbonates which are dissolved in the water are decomposed, lose one half of their carbonic acid, are precipitated as insoluble carbonates, and produce the first deposit in the boiler. During the subsequent continuous evaporation of the water, the other compounds dissolved in it are concentrated and finally precipitated, when the limit of their solubility is reached. Another kind of deposit is thus produced, different from the first in its chemical composition. The great variety of chemical compounds dissolved in different feed-waters, is a proof that no general chemical means can exist, fit to prevent all incrustation from any water, and that every chemical remedy proclaimed as universal, is to be considered as an imposition. A certain substance cannot even prevent the formation of a certain kind of incrustation unless it is added before the water is brought into the boiler, thus precipitating and gathering the solid compounds outside of the boiler. A chemical analysis of the feed-water can alone give a correct idea of the value of one or other of these chemical remedies for special circumstances. Another method of relieving the feed-water of the greater part of dissolved matter, consists in pre-heating the water in a specially adapted vessel or apparatus, where it then deposits its carbonates. An excessive concentration of the other matters can be prevented by allowing a certain quantity of the contents of the boiler to run out every day, and by replacing it by fresh water.

A third kind of remedy against incrustation does not attempt to prevent the formation of deposits, but alters the nature of these deposits so that they do not adhere, by introducing such matters or arrangements that the deposits may be gathered upon them, and with which they can be quickly and easily removed. We reckon amongst these reme-

dies: painting or covering of the interior of the boiler; mechanical admixtures to the water, which are said to rub and clean the interior boiler surface; the many existing mysterious substances, one of which, viz: Baker's anti-incrustator, has succeeded in acquiring a wide-spread but totally undeserved reputation.

An apparatus invented by Schmitz, and based on a new principle, was favorably received at the last Paris exhibition. By inserting curved wrought-iron plates into the boiler, Schmitz intended to create a regular circulation of the water, thereby to increase the evaporating power of the boiler, and to carry all precipitated matter to the upper surface of the inserted plates. This object is attained in a much more complete manner by Popper's anti-incrustator, and it has been shown most conspicuously by a trial made with it in November, 1868, in the machine shop of G. Sigl, in Vienna, (Austria)

Popper's apparatus, a section of which is represented by the annexed sketch, consists



of long strips of sheet-iron about 12 in. wide, which are introduced through the manhole into the boiler, and there united so as to form a half-cylinder, placed parallel to the lower half of the boiler. Little projections attached to the outside of this half-cylinder prevent the latter from coming in direct contact with the boiler, but keep it at a certain distance above the interior boiler surface. This distance must be pretty short to make the apparatus very effective. In Sigl's boiler of 4½ ft. diameter as used for the trial, this distance was 2½ in. below the cylinder, and only 1¼ in. at the sides. So far, the arrangement is not very different from that of Schmitz. But Popper made a very important addition by inserting a row of vertical pipes of sheet-iron, five inches in diameter, and placed about 24 in. apart. These pipes are supported by the cylinder which has corresponding openings so as to effect a central communication between the water above and below the cylinder. The whole apparatus is set in loose, and kept in place by the weight of a thick layer of pebbles of egg size covering the lower part of the half cylinder. These pebbles, besides, perform the function of taking up all the deposits from the water.

The manner in which this apparatus acts, is indicated by the arrows in our engraving. The steam generated at the heating-surface, rises rapidly in the space between the boiler and the cylinder, creating a strong current, the most important factor of an economical steam-generator. But it does more. The vehemence of the evaporation and the rapidity of the current, prevent all precipitated matters from settling on the boiler plates and throw these matters, together with the water, several inches above the upper rim of the half-cylinder. As this rim is at a level with the lowest water-line, this arrangement is also a protection against the dangergerous consequences of sinking the water below that line. It could be seen distinctly in Sigl's trial-boiler that the water was thrown five or six inches above the normal water-level. It is even to be expected from this system that a continual washing and wetting of the interior boiler walls will take place so long as any notable quantity of water is left in the boiler.

The vertical pipes carry the water back to the heating-surface.

A certain part of the water is always quiet in the interstices between the big stones, where it deposits all the precipitates.

The apparatus is simple and cheap. The boiler in which Popper's apparatus was tried in Sigl's machine works in Vienna, presented a surprising appearance after an uninterrupted working period of three weeks. The interior of the boiler was so perfectly clean, that small impressions which had been made by the hammer during a previous cleaning operation, were yet to be seen dis-

tinctly. Also the outside of the half-cylinder was free from incrustation, and showed a metallic surface. The stones were covered with a thick crust of deposits, and so also was a part of the upper surface of the half-cylinder and of the vertical pipes.

To clean the boiler, nothing has to be done but to replace the stones by fresh ones. To do this easier and quicker, the stones will in future be laid into appropriate metallic troughs, in which they remain when in the boiler.

The work of the boiler was regular and undisturbed during the whole trial. The first heating-up was done quicker, the generation of steam was more rapid than usual. According to exact and careful observations, the priming was not more considerable than before. The consumption of coal was very low. As, however, no exact notes were taken about this, the economy of fuel effected by the apparatus could not be calculated for this trial.

Experiments on the applicability of Popper's system on Cornish ship and locomotive-boilers are in preparation, and will doubtless prove as successful as the above.

S.

HISTORY OF WATT'S STEAM ENGINE.

From Sir Wm. G. Armstrong's Inaugural Address before the Institution of Mechanical Engineers, at Newcastle.

This year is the centenary of the steam engine of Watt; and I am glad that it has fallen to the lot of Newcastle to receive, on so auspicious an occasion, a society which must regard Watt, more than any other man, as the father of their calling. First, then, I shall discharge my duty as your president, by paying a tribute of respect to the memory of the illustrious man who, in the corresponding year of the last century, completed and set to work the greatest of mechanical inventions.

In 1765, the authorities of Glasgow College, little thinking of the momentous step they were taking, intrusted a model of a Newcomen engine to James Watt, a maker of mathematical instruments, for repair. The sagacity of Watt enabled him, by an inspection of the model, to detect a radical defect in the principle of the engine. He saw that the condensation effected within the cylinder reduced its temperature, and rendered restoration of the wasted heat necessary at every stroke. He perceived that the steam ought to act in a vessel always hot, and be condensed in a vessel always cold. He thus conceived the idea of separate condensation. With a quiet tenacity of purpose he set to work, under great disadvantages, to realize his idea of a more economical steam engine. His design was soon matured, but the difficulty of execution long remained a barrier to practical success. In the Newcomen engine, the weight of the atmosphere, acting against a vacuum, was the moving power, and leakage of air past the piston was prevented by water resting on the upper side. An unbored cylinder, made in separate parts, sufficed for this arrangement; but in Watt's design steam instead of air acted on the piston. A water packing was inapplicable, and leakage could only be prevented by the more accurate fit of the piston in the cylinder. A moderately steam-tight cylinder and piston were, however, more than the workshops of the day could produce, and we read of his vain attempts to correct, by pasteboard and cork, inaccuracies of workmanship, such as in our time has no existence.

With ailing health, narrow pecuniary means, and a temperament inclining to despondency, he was, in many respects, unfitted for a struggle with difficulty; but he was a man whose mind was taken captive by an idea, and he could not help persevering. His attractive character and fine intellect had attached to him many valuable friends, superior in station to himself, and his letters to some of those friends, written during his struggles, exhibit at once his severe discouragement and his irresistible impulse to proceed.

In 1768, he had succeeded in producing a condenser with its necessary appendage of an air-pump; but it was not until the following year, 1769—exactly a century ago—that his first complete steam-engine was finished and put in motion. The first trial was made by Watt in a secluded glen, behind the house of his friend, Dr. Roebuck, near Linlithgow. The engine was not a mere working model, but a machine of considerable power. It had a cylinder of 18 in. in diameter, and a stroke of 5 ft.; but the cylinder and piston, which were described as the best the Carron Ironworks could produce, were still so inaccurately made as to defeat, in a great measure, the anticipated success. The engine, however, afforded a practical demonstration of the value of the invention sufficient to lead eventually to the happy alliance of the capital of Boulton with

the genius of Watt. In 1773, the engine was removed to Mr. Boulton's works at Soho, and was fitted with a new cast-iron cylinder, the casting and boring of which were deemed no small achievement in those primitive days of mechanical engineering.

This first engine of Watt was, like that of Newcomen, only applicable to pumping, but Watt quickly saw by what modifications it could be rendered available for rotative motion. By a succession of brilliant inventions, comprising, amongst others, his parallel motion and his ball governor, he advanced to the final conception of the double-acting rotative engine, which became applicable to every purpose requiring motive power, and continues to this day, in nearly its original form, to be the chief moving agent employed by man.

To do full justice to the genius of Watt, we must consider the disadvantages under which he labored. In the present day, every contrivance is practicable in a constructive point of view, and the vast variety of devices used in modern mechanism, and applicable to new mechanical combinations, are made known to inventors in minute detail by the press. But Watt had no such facilities. He had to draw from his own mind what we can now choose from pre-accomplished invention, and his choice of means was restricted to the narrow limits of what was practicable in the rude workshops of the period. If we give due weight to these considerations, we shall be able to appreciate the remarkable originality of his mind, and the sagacity displayed in his invention. Watt lived to see his steam-engine bear fruit in marvelous utility to the human race; but he could have had no idea of the results it was destined to realize before the first century of its existence. It is impossible to contemplate these results without feelings of enthusiasm. To appreciate how much we owe to the steam-engine, we need only consider for a moment what our positions would be if we were deprived of its agency. The factories which clothe all the nations of the earth would be almost extinguished. The deep mines which supply nearly all our mineral wealth would be abandoned. The manufacture of iron would shrink into comparative insignificance. Horses and sailing ships would again become our only means of transit. All great engineering works would cease, and mankind would relapse into that condition of slow and torpid progress which preceded the subjugation of steam by Watt.

PERMANENT WAY.

Compiled and adapted from "Polyt. Centralblatt."

A great number of engineers are of the opinion that to obtain a solid and permanent railway, causing the least possible maintaining expenses, the wooden cross-ties should be removed, and replaced by more durable materials. The plans which have been designed for this purpose, are principally the following:

1. To lay the rails on stone blocks.
2. To lay the rails on piers of cast iron.
3. To replace the wooden cross-ties by iron ones.
4. To lay stiff and strong, or broad footed rails, directly on the ballast.
5. To lay the rails on longitudinal wrought iron sleepers, in the ballast.

The first method has been introduced on some lines in Bavaria and Wurtemberg, and works satisfactorily when well and solidly constructed. The second method is in use on a larger scale in Egypt, Algeria, England and the East Indies, and a trial is just being made with it on the small route between Leipzig and Magdeburg. Both these systems of construction are not to be recommended for use on a new embankment, because when the latter settles they yield too easily, and cause disturbances in the track.

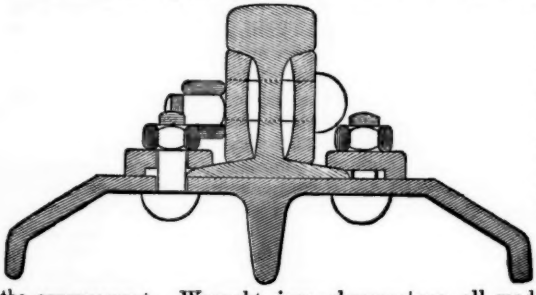
Iron cross-ties are used on some lines in France, Belgium and Spain. Vautherin's system, especially, has been introduced on the French Northern Railroad, and recently on the Saarbruck Railroad. The rails are fixed to the ties by wedges. This system is more appropriate to new railroads than the two former, as the width of the track cannot be altered by the settling of the embankment. But the construction requires much iron, and is, therefore, very expensive. It is, besides, to be feared that the wedges used may not stand long, and that they may widen the wedge holes, and become loose after some time.

The fourth method of constructing permanent way, consists in laying very rigid and strong rails directly on sand or gravel, or crushed stone. This method has been tried with satisfactory results on the Cologne Minden Railroad, where rails 8 in. high, made after the design of Mr. Hartwich, were used for the purpose. These rails were joined by fish-plates 2 ft. in length, with eight screws of 1 in. diameter. The plates are strong and well designed; their moment of inertia being equal to that of the

rails. The cost of the iron on this road amounted to 2.65 Prussian thalers per foot ($1.85 gold). If the rail is laid directly on gravel, its foot has to be very broad to get a sufficiently large bearing, or the rail has to be very high to reach as deep below the surface of the gravel as possible. Both ways involve great inconveniences. A very high rail especially, is liable to tip over. Mr. L. Clasen, of Hanover, therefore proposed to lay such rails on a foundation of concrete, imbedded in the gravel. Concrete when well prepared, is a cheap, strong and durable material for railway substructure, and can be easily obtained everywhere. For the purpose of attaching the rail, Mr. Clasen proposes to lay a plate with a small rectangular hole into the concrete about 1 ft. deep, to leave a narrow hole open, extending from the hole in the plate to the surface of the concrete. A bolt, with a hook of peculiar construction at its lower end, would be inserted into the hole and hooked on to the rectangular hole in the plate. The rail would be kept in place by being screwed on to several of these bolts. The latter could be easily removed when broken, and replaced by new ones. The rails have to be joined by strong fish plates, with four screw bolts. To prevent the rails from giving way sidewise, it is proposed to join two opposite rails by wrought iron flats, laid below the foot of the rails, and bent upwards on both sides of the track. This plan has not yet, however, been tried practically.

A very successful trial has been made on the Nassau Railroad (Prussia), with the fifth of the above mentioned methods of railway construction.

The annexed engraving shows a section of



the arrangement. Wrought iron sleepers are laid in gravel or sand, parallel to the track. On these sleepers light rails are fixed by means of small plates, and short screw bolts, and joined by fish-plates. The width of the track is preserved by thin wrought iron cross-ties connecting two opposite rails.

As this system seems to be a decided success, we give in the following a more detailed description of it, as published in "Polyt. Centralblatt," by Mr. M. Hilf, of Wiesbaden.

1. *Rails.*—The rail used has a broad foot and pretty sharp angles below the head, so as to allow of the application of a strong fish-joint. Its weight is little over 51 lbs. per yard, which is about two-thirds only of the weight of the rails used on the same railroad with the ordinary wooden substructure.

The fish-plate has been recognized as the most reliable means for joining the rails. They are, besides, joined below, the ends of two adjacent rails being attached to the same sleeper. This gives a high degree of solidity to the whole system.

The rails have a length of 19 ft. 8¼ in., and are slotted in two places near the middle, and clinched by two of the fastening bolts to prevent the rails from creeping. Every rail is attached to the sleepers by eighteen screw bolts, the nuts of which work on small plates, which clasp the foot of the rail, as our engraving shows. The total weight of the eighteen bolts, nuts and plates, necessary to fasten one rail, amounts to 23 lbs. The fastening effected by these means is so solid that its safety is not much endangered if some of the nuts should become loose, which however happens but very rarely. The same straight sleepers are used for laying curved tracks. The bolt holes have then to be drilled into the sleepers so as to correspond to the required curves. Five different templets are sufficient to mark the bolt holes for all the curves of from 900 to 6,000 ft. radius. The sleepers have then of course to be laid in a position parallel to the tangent of the curve. The rail being light, does not want to be bent previous to laying, and a curved rail can be turned round when one side of its head is injured.

2. *Sleepers.*—The sleepers are easily rolled into the shape indicated by our drawing. They are all made of the same length, which is 19 ft. 2¾ in. They are about ½ in. thick, and weigh 79¼ lbs. per yard. Sleeper and rail together are so strong that when laid on supports 3 ft. apart, they are not strained

beyond the limit of elasticity by a weight of 36,000 lbs. As the load pressing on the whole system when in use, is distributed on a pretty large surface, this strength offers more than sufficient security. The shape of the sleeper is such as to present two concavities below, into which the material that forms the bed can be rammed in solid. This material cannot, therefore, give way sidewise, but it becomes the more solid the greater the load pressing on the rail. In fact, the whole construction acquires the more steadiness the longer it is in use. The sleepers themselves are so strong that they will not have to be renewed for a very great number of years.

3. *Cross-Ties.*—There are three wrought iron cross-ties on every 20 ft. of track; that is, on the length of one rail. They connect two opposite rails directly, having a screw at each end which passes through a corresponding hole in the web of the rail. Two nuts outside, and one inside of the rail, fasten the latter to the tie. The length of the ties is 5½ ft. Three ties with their nuts and washers, weigh together 53 lbs.

The strength and number of these cross-ties is more than sufficient even in sharp curves. The double nuts on the outside are not absolutely necessary, but are safer, especially with sharp curves.

The cross-ties are easily detached, when rails have to be exchanged. The enlargement of the track in the curves can be exactly regulated by the ties and the nuts.

The total weight of the construction above described, is for the length of one rail as follows:

Two rails 19 ft. 8¾ in. long, 51 lbs. per yard	669 lbs.
Two sleepers 19 ft. 2⅞ in. long, 79¼ lbs. per yard	1,016 lbs.
Thirty-six screw bolts, with nuts and small plates	46 lbs.
Three cross-ties, with twelve washers and eighteen nuts	53 lbs.
Two pairs of fish-plates, with eight screw bolts	44 lbs.
Total weight for one rail-length	1,828 lbs.
or 278 lbs. per yard.	

The total and full cost of the whole iron superstructure, including the laying, was 9$\frac{8}{10}$ Prussian thalers per meter, or $6.32 gold, per yard of track. The expenses for maintaining a track of the above construction are very small.

A length of 490 yards of this track was laid in 1867, in the station at Asmannhausen, on the Nassau Railroad. The ordinary kind of rails was used. A part of the rails were fastened to the sleepers by rivets instead of screw bolts. 380 yards of the said track were laid in curves of 500 to 700 yards radius. Eight trains were run over the track daily. None of the rivets or screw bolts had become loose, and no part whatever of the track had been deranged at the end of the year 1868. The gravel on both sides of the rails and sleepers has grown hard on the surface, and the crust thus formed never shows the least cracks, which proves the solidity of the construction. The trains run smoothly over the track without any concussion at the joints of the rails. No bad influence of the weather has been observed, although the drainage of the track is very imperfect. The position of the sleepers has not been disturbed by a temperature as low as 5° F. above zero.

In consequence of the excellent results of this trial, a similar track was laid between Ober-Lahnstein and Ems, on the Nassau Railroad, a distance of about two German miles, containing several curves of 330 yards radius. This line is completed, and proves to be a perfect success. The trains run steadier and with less noise over this track than over the rails laid on wooden cross-ties. The iron sleepers lie perfectly firm. The rails do not alter their position in the least, not even when the cross-ties are removed, and when the trains run over the track at full speed. This shows that two cross-ties per rail would be quite sufficient, especially on straight lines. A part of the above mentioned line was laid down in such a manner that every single rail rested on a single sleeper, the joints being thus suspended. This was done because it was feared that the motion of the cars would not be perfectly smooth with fixed joints. This apprehension was, however, not verified, and as the latter arrangement gives the track a greater solidity, it will be preferred in future constructions upon this system. S.

THE CREEPING OF RAILS on a double track, where all the trains run way over them, has got to be a very serious matter with our old fashioned methods of laying. The spikes used with a common chair are utterly inadequate; with a continuous-lipped chair they answer tolerably. But the Reeves chair makes a better joint than either—better than the fish-joint with low rails—and it entirely prevents creeping.

LIGHTING COAL MINES.—The awful loss of life which has been occasioned, both in this country and abroad, during the past few years by colliery explosions, is at last, we are glad to see, in a fair way to receive the attention it merits; and we trust that the next session of Parliament will not be allowed to pass without some material improvement being made in our legislation on the subject of colliery management. It is quite time, not only that the thoroughly efficient ventilation of coal mines should be rendered compulsory by law, but also that means should be adopted to ensure that the law is carried out. Quite apart from the ventilation, also, means should be taken to ensure the proper lighting of coal mines, and this lighting should be so effected that, even in the event of the ventilation of a portion of a mine becoming temporarily deranged from accidental causes, no harm could result. The safety-lamps now used, though no doubt excellent in their way, give but a very miserable light, and those who have studied the causes of past explosions, well know that these have been in many instances caused by miners opening their lamps to get a little extra illumination. The surfaces of a coal mine, in fact, possess such great light-absorbing power, that none but a very powerful light can be regarded as a really efficient one.

Bearing these facts in mind, Mr. Henry Bessemer, in a letter addressed by him to the "Times" a few days ago, has suggested a method of lighting coal mines which appears to us well worthy of careful attention. As some of our readers may be aware, Mr. Bessemer has been lately engaged in investigating the action of combustion under high pressures, and the results which he has obtained have led him to consider that lamps in which the combustion goes on under pressure exceeding that of the atmosphere, might be advantageously employed for lighting mines. Thus, he states, for instance, that an iron box, having one side fitted with a bull's-eye, or formed of thick plate glass, may be fitted with an ordinary gas-burner, supplied with gas from a gasholder above ground, and that the air to support combustion may be supplied to this box by a suitable pipe at a pressure of, say, 1 lb. per sq. in. above the pressure of the air in the mine, a small hole being left at the top of the lamp for the escape of the products of combustion. Under such circumstances not only would the light produced by the combustion of the gas be intensified, but the pressure within the lamp being in excess of the surrounding atmosphere, the latter would be prevented from entering, and consequently, even if an explosive mixture existed in the mine, it would be perfectly safe from ignition.

Such is Mr. Bessemer's plan, and an admirably simple plan it is. By the aid of a series of brilliant lights, such as he proposes, the galleries of mines may, as he says, "be lighted like a workshop," and there is really, as far as we can see, no good reason why this should not be done. The supply of air and gas, under suitable pressure, presents no practical difficulty, and by the aid of suitable reflectors, one powerful lamp, such as we have described, would be enabled to give a good light for some considerable distance around it. By the aid of easily contrived arrangements, also, some of the lamps might be made to a certain extent portable if required, but in such a case care would of course have to be taken to protect the glasses from accidental fracture. Mr. Bessemer states that he is "convinced that the thorough lighting of a coal-pit, and its ventilation so as to insure health and safety to the miners, are purely a question of £ s. d.," and in this opinion we perfectly agree with him. We do not consider, however, that in matters of this kind any question of expense should be allowed to interfere with the adoption of thoroughly efficient arrangements, and we think that it should be placed beyond the power of any colliery proprietors, actuated by parsimonious motives, to risk the lives of the men employed by them. As in the case of boiler explosions, the experience of past years has taught us that a knowledge of the risks to which they are exposing not only themselves, but others, is not of itself sufficient to make all men adopt means to avoid these risks; and it is, we think, time that both boiler owners and colliery proprietors should be made to feel their responsibilities more strongly. How this can best be done is a matter which we shall not discuss here, as it is to a certain extent foreign to the object of the present article, which was specially to bring before our readers the system of lighting we have already described, a system, we may add, which has not been patented. The fact of a good invention being public property, has but in too many instances proved to be a bar to its adoption, as it has been nobody's interest to show that it was the "right thing

in the right place;" we hope, however, that Mr. Bessemer's plan may prove an exception to this rule, and that it may shortly be tested on such a scale as to demonstrate its practical merits.—*Engineering.*

STEAM ON CANALS.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle, by Mr. MAX EYTH, of Leeds.

In the application of steam power to river and canal navigation, the writer remarked, the greatest obstacle to be encountered had been the loss of power that was inseparable from the ordinary methods of propulsion by paddle-wheels or screw propellers. As the resisting water formed the fulcrum upon which the bearing was taken for propelling the vessel, the result was that a great quantity of water was put in motion, and a considerable amount of power exercised without any useful effect being produced. Thus even under the most favorable circumstances, when working on a broad sheet of deep water, the ordinary propellers lost from 40 to 50 per cent of the power applied to them; and, under the peculiar circumstances met with on rivers and canals, their useful effect was frequently reduced to less than 25 per cent of the power applied. On canals, the increased difficulty to be encountered arose from the presence of locks, the small section of water through which the boats had to be driven, and the swell produced by the increased speed of the boats, for which the small section of water was not originally calculated. Moreover, as the only admissible means of propulsion was by screws or paddle-wheels placed at the stern, the water put in motion by them was withdrawn from the stern of the tug, and thrown against the bows of the boats in tow; the water-level in the canal was thereby disturbed, and the hollow created at the stern of the tug had to be filled up by the water in front of the tug running backwards through the narrow passage left between the tug and the sides of the canal. The consequence of this was that engines of considerable power had to be used for towing a given freight; and hence, owing to the small size of the locks through which they had to pass, it was of the utmost importance that the engines employed should occupy as little space as possible in the holds of the vessels, in order that the cost of steam propulsion might not be further increased by a source of diminution in the amount of freight that could be carried. As it was admitted that a dead pull from a fixed point was undoubtedly the most effective mode of gaining power, it had now been determined to adopt a system on canals and rivers of towing by means of a fixed wire rope and clip drum. The rope was laid in the bed of the river or canal from end to end, being anchored only at its two extremities, and an engine on the deck of the boat was then attached to the rope, and wound itself along to its destination. The idea was not altogether new, as attempts had been made on the Rhine by the French Marshal de Saxe, as early as the year 1732, to transport war material through different rivers of the country by means of a horse windlass on the boats, which wound up a rope made fast on the bank of the river at the extreme end. In 1820, a regular service on the same principle was established on the Rhone, by Tourasse, and it successfully overcame the difficult portions of the river between Givers and Lyons. After noticing the drawbacks of the plan, however, and the many obstacles in the way of a free use of chains or winding drums, the paper added that the present system—consisting of a clip drum working along a submerged wire rope—had been invented and matured by Baron Oscar de Mesnil, a Belgian gentleman, and the author himself; the first experiment having been made at Leeds, in 1866, for Joseph Fowler & Co., and since repeated more extensively on several American canals and also in Belgium. The first application of the submerged wire was made on the river Meuse, where a line 42 miles in length—from Namur to Liège—had been in successful operation since 1868, and was now being extended 90 miles through the Canal de la Campine to Antwerp. Having described the Canal de la Charleroi, in Belgium, the writer added that one of the boats on it was 42 ft. long, by 8 ft. broad, and drew 3 ft. water; while the wire rope, $\frac{5}{8}$ in. in diameter, wound round a 5 ft. clip drum. In addition to these there was a winding drum used for the purpose of obtaining a sufficient amount of slack in the rope for enabling the tug, when off the rope, to hitch on again at any place without delay. The speed of the engines here, 10-horse, was 80 revolutions per minute with 90 lbs. pressure of steam, and the speed varied from one to three miles; but on the river Meuse they had engines of 14 horse-power, working up stream at from three to six miles an hour, although on the downward journeys this

could be increased to ten miles by running the engine at 120 to 130 revolutions. In some places, also, they had smaller boats fitted with portable engines—engines that could easily be transferred from one boat to another; and while these were, by a very ingenious contrivance, enabled to pass through the narrowest parts of a canal or the lowest bridges, they could easily travel at 2½ miles an hour with two 200-ton barges fastened behind them. The ropes were in all cases laid along the side of the deck, and never being very long exposed to the air they were not liable to injury by oxidation, neither were they subject to fracture or obstruction on the bed of the river. The rope used on the river Meuse was only 1 in. in diameter, of iron wire, the greater part being galvanized, and having a breaking strain of 14 tons. The weight was 4¾ lbs. per yard, and cost, including the laying down, £93. The maximum work done by one tug of 14 horse-power, was towing 18 boats containing a total cargo of 1,000 tons; while, by another, 1,500 tons of freight was towed by 10 boats. Both trips were made up stream, and at from 2½ to 3 miles an hour, including stoppages. The average work of the tugs was to tow 700 to 900 tons of cargo, in 8 or 12 boats of different sizes—the steering in all cases being good—while the average amount of coal consumed by the 14-horse tug amounted to three-quarters of a hundredweight per mile, and the working expenses to £22 per month. The cost of towing on the canals, where the system was now in operation, amounted to not more than .05d. (or one-twentieth of a penny) per ton per mile, including the working expenses, the management, the interest, and the redemption of capital. This result was not only another illustration of the great advantage which inland navigation possessed over any other mode of carrying heavy traffic where speed was not required, but it also proved the important commercial value of this particular mode of towing, as compared with any of the other methods hitherto in general use. The average cost of towage by animal power on four English canals, amounted to .35d. per ton per mile, and on seven French canals was .27d. With paddle tugs on the Thames the cost was .48d., and on six rivers in France it was as high as .80d. per mile. The employment of screw tugs on three English canals resulted in an average cost of .27d.; whilst towing by boats carrying their own machinery cost, on seven English canals, .20d. per mile. In conclusion, the author remarked that while railways had undergone so wonderful a development during the past thirty years, the quieter, but often more important, mode of transporting heavy goods by inland navigation had remained comparatively neglected. It was true that the natural features of England were not very favorable for inland navigation, although there was in the United Kingdom a total length of 2,000 miles of navigable water courses; but on the Continent, in the colonies, and especially in India, there was a vast amount of traffic for which no better highways could be found than those already traced by nature in the rivers and streams penetrating the interior of the country. The system of wire rope towing that had now been described, placed inland navigation in a similar relative position to that in which the road traffic was placed by the introduction of the railway and the locomotive. By means of the clip drum, the tug obtained a hold upon the flexible rope laid on the water course precisely in the same manner as the driving-wheel of the locomotive took hold of the rigid rail upon which it ran; and the great advantage of steam-power might, therefore, be similarly brought to bear on the movements of vessels in water—leaving to railways all their superiority in regard to speed, but restoring to rivers and canals their advantages in reduction of traction.

MECHANICAL FIRING OF STEAM BOILERS.

By Mr. John Daglish.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle.

The first part of this paper contains the results of a series of experiments that were arranged and carried out by the writer at Rainton Colliery, chiefly for the practical determination of the question of the utility and economy of side water boxes in connexion with Juckes' furnaces, and incidentally to ascertain the advantage derived from covering boilers, and the best materials for that purpose. A second series of experiments were then given that were conducted at Seaham Colliery, for the purpose of practically ascertaining with certainty the advantages obtained by the use of mechanical apparatus as compared with firing by hand, and the comparative advantage of various systems of mechanical apparatus. Incidentally, attention was drawn to other points, and experiments were made to ascertain the best rate of motion for the bars, thickness of fire,

and distance of boiler from firegrate. A third series of experiments were then given that were conducted at Silksworth Colliery, for the purpose of determining the relative advantage of the Cornish boiler for colliery purposes, as compared with the plain cylindrical boiler, prior to erecting a large number for the extensive new coal winning which is now proceeding at Silksworth. Incidentally, the experiments were carried out with different qualities of coal, for the purpose of ascertaining their comparative economic effects. The first series of experiments were made at the pumping engine at Rainton Colliery, which is well adapted for experiments of this kind, as the engine is going continually at an uniform speed. The boilers are in one range, are all of the same size and description, and the temperature of the water was taken alike throughout. They are fitted with Juckes' mechanical firegrate, consisting of an endless chain of short longitudinal bars, traversing forwards with a slow, continuous motion, and thus conveying the fuel from the hopper by a self-acting operation. Nos. 1 and 2 were covered with one description of boiler-covering composition, and were fired by Juckes' mechanical furnaces, 4 ft. broad; while two wrought-iron pipes, 2 in. in diameter, were placed on the inner end, 1½ in. above the bars. These pipes were necessarily exposed to the action of the furnace heat, and, in order to prevent them from being burnt, were constantly kept filled with water. Nos. 3, 4 and 5 boilers were also fired by Juckes' furnaces, to which were added Coulson's water-boxes. These are the full length of the furnaces, 7 in. square, made of half-inch wrought iron; on the inner end they are connected with the boiler by pipes, and have at the outer end a sludge pipe, to remove any scale from the boiler. Nos. 3 and 5 boilers are covered with different kinds of boiler-covering composition, whilst No. 4 is not covered at all. The height of the bottom of the boilers above the fire bars was 2 ft. in three of the boilers, and 1 ft. 6 in. in the others. The quality of coal used was peas, or screened small steam coals; the same quality being used in all the experiments, and the exact quantity of coal used was carefully noted. The time taken in consuming the coals was also noted, together with the number of gallons passed through the special feed pipe; all connexion with the other boilers being shut off. The strokes of the engine were also taken during each experiment by means of engine counters. The result of these experiments may be generally stated to be:

	Pounds of water evaporated per lb. of fuel.
1. With boiler covering, without water-boxes, and with boilers 2 ft. above firegrate.....	4.83
2. Without boiler covering, with water-boxes and boiler, at 1 ft. 6 in. above fire-grate.....	4.66
3. With boiler covering, with water-boxes, 1 ft. 6 in. above fire-grate,	5.02
4. With boiler covering, with water-boxes, 2 ft. above fire-grate....	5.38

The advantages of water-boxes in increasing the evaporative power of a boiler, as well as in the increased economy of fuel, are therefore very considerable, but those advantages are to a great extent neutralized by the difficulties and increased expense in upholding those boxes. There might be circumstances, however, when their use would be attended by ultimate economy. The advantage of having the boilers at a distance of 2 ft. above the firegate, as compared with 1 ft. 6 in., is also shown by these experiments. With 1 ft. 6 in. distance the effect was 5.02, as compared with 5.38 with a distance of 2 ft., showing an advantage in the latter of more than 6 per cent. It is also found in practice that the boiler is much less injured by the action of the heat at the greater distance. The second series of experiments was made with the range of boilers of the Seaham winding engine, and they are under cover of a boiler house. The boilers are all of the same dimensions, being ordinary egg-ended cylindrical boilers, with a straight flash flue going into the main flue. No. 1 boiler was fired by hand; the heated air, after passing along below the boiler, returns by a side passage, and travels all around the boilers before entering into the chimney. After the wheel flue experiments were made, the flue of this kind was made into a straight flash flue. No. 2 boiler was first fired by hand, with a straight flash flue running direct into the main flue, and was afterwards fitted up with Stanley's self-feeding mechanical furnace. No. 3 boiler was fired with Vicar's self-feeding furnace. Nos. 4 and 5 boilers were fired with Juckes' furnace, of the same description as those already experimented on at the Rainton Colliery pumping engine. From the experiments shown in the accompanying table, the following deductions may be made: First, with hand

firing, the quantity of water evaporated per pound of coal, with a flash flue, is 6.66 lbs. as compared with 5.22 lbs. with a wheel flue; and the total quantity of water evaporated is 441 gallons per hour, as compared with 433 gallons per hour, showing the marked advantage of the flash flue over the wheel flue, not only in the economic effect of fuel, but also of boiler space. It is probable, however, that this amount of economic effect (6.66) is considerably higher than that obtained under ordinary circumstances, as the fires were more regularly attended to than is usual with hand firing. Secondly, Juckes' furnaces. This apparatus, invented for firing steam boilers, has been in operation some time in this district, and has lately been adopted very largely at many collieries in the north of England. The advantages of this furnace are, perfect combustion of smoke, and great regularity in raising steam; the saving, in common with other mechanical appliances, in the wear and tear of boilers and in manual labor in stoking, the latter amounting probably to £200 per year per boiler. In comparison with hand firing, it does not seem to possess any great advantage in economy of fuel, the comparative economic effect being 5.09 as compared with 6.66 for hand firing; but the latter is probably a much higher result than what is usually attained in practice. Like all other mechanical appliances, it requires a certain amount of care and attention in its use; but on the whole it may be said to be successful and economic in application. It is not well adapted for using Duff coal, although this is done in some instances when the Duff is washed. Thirdly, Vicars' furnaces. Of all the mechanical apparatuses for firing steam boilers, none seem to be so successful as Vicars', as arranged at Seaham Colliery, though this apparatus, erected elsewhere, seems not to have worked satisfactorily, which was probably owing to the improvements recently made in the apparatus. These now consist of three distinct appliances. The traversing bars, intended to give progressive motion to the incandescent fuel, by a slow alternate and intermittent longitudinal motion; second, the pump feeders, which alternately press a regular supply of coal from the hopper to the bars; third, the water troughs, in which the fire bars are immersed, and which are absolutely essential, as no ordinary fire bars can withstand the intense heat of the fire. This furnace was in constant operation at Seaham Collieries for nine months without requiring any repairs, and in all respects it has been most successful and economic. When using the same class of coal (peas) as in the hand-firing experiments, the economic effect was 7.14, as compared with 6.66; but the maximum results of this furnace have probably not yet been obtained, nor the best conditions as to thickness of fire ascertained, the high amount of 8.78 lbs. of water evaporated per pound of coal being in one instance obtained. This furnace is very efficient in its action in avoiding the formation of smoke. The great advantage, however, attending the use of the furnace is its applicability to the use of Duff coal, or dust coal, with high economic effect. It will be observed that with dust coal the economic effect actually reached is 6.84 lbs. of water per pound of coal. Taking the consumption of fuel in one of these experimental boilers at six tons per day of 24 hours, and taking the comparative price of Peas and Duff coal at 3s. and 1s. per ton at the pit, the commercial economy effected by the use of these furnaces over any other mechanical apparatus not adapted to use Duff coal will be from £200 per year per boiler. The evaporative power of the apparatus does not appear by these experiments to be equal to that of Juckes' or hand firing, although this may arise, as before stated, from the fact of its maximum power not being yet perfectly developed. A somewhat interesting circumstance may be observed in these experiments. The fire-bars used in this special fire are 5 ft. 4 in. in length, whilst those in Juckes' apparatus are 6 ft. 6 in. in length; but although the heat of the fire in Vicars' grate was much more intense than in the Juckes', the pyrometric observations in the flue beyond the boiler invariably showed much lower temperature from the former than from the latter. It would seem, therefore, that the heat developed in the grates of the Vicars' is of considerably higher intensity than that of the Juckes', and as effectual in its action on the exposed surface of the boiler, so that the absolute heat remaining on arriving at the flue is then reduced below that of Juckes'. The experiments with Stanley's apparatus give very irregular results, showing that a lengthened series of experiments, as to speed of dispersers, thickness of fire, etc., would be required before the maximum effect could be regularly attained. In this apparatus, the

coal falls through crushing rollers on to two dispersers, or rapidly revolving discs with radiating ribs, which scatter the coal uniformly through the fire by centrifugal action. The advantages of this furnace are that it permits of the use of Duff, or dust coal, and a comparatively large amount of fuel can be consumed per square foot of fire-grate surface. As compared with hand firing, a much lower economic effect is exhibited, being 4.74 against 6.66; but it is more than probable that this arises from the Stanley apparatus not being in all respects arranged to obtain its maximum effects. A few experiments were made with this furnace after the addition of Whittaker's traversing bars, but not sufficient to yield any reliable data. The third series of experiments with single tubular boilers were made with two boilers erected at Silksworth Colliery, for temporary purposes, which were fortunately of exactly the same size, and were constructed with a single tube. They had been previously in use at the Londonderry blast furnaces blowing engine, and were then set over the fire-grate, the draught returning through the tube and thence round each side of the boiler. At Silksworth one of these boilers is set in a similar way, the other having a fire-grate fitted up in the tube and used as a Cornish boiler. This series of experiments was intended also to show the useful effects of external heating surface, and by an arrangement of dampers the smoke could be either taken at once up the chimney, or made to pass all around the outside of the boilers by the external wheel flue. The following are the chief deductions to be drawn from these experiments: First, the advantage in No. 1 boiler, of using the wheel flue, overtaking the smoke direct through the tube to the chimney, is as 5.51 to 4.87; secondly, there is a slight disadvantage in No. 2 boiler using the return tube through the boiler and the side flues, instead of taking the flame direct from under the boiler to the chimney, being as 4.72 to 4.94. The general results of these experiments tend to show the advantage of flush flues, having the usual large heating surface. The most important point, however, to be deduced from the experiments was the small evaporative power of the boilers when fired through a single tube, as compared with the result of firing underneath the boilers, being only 604 and 690 gallons evaporated by the former as compared with 1344 and 1243 by the latter method, the economy of fuel being about the same in each case. The chimney, however, used for these boilers was only temporary, and not capable of producing a draught sufficient for the wheel flues. This fact renders it impossible to make any comparison between these experiments and those made at Seaham Colliery. It must be borne in mind that these boilers are by no means fair specimens of the Cornish boilers; and arrangements are being made to carry out a series of experiments to ascertain the evaporative power and economy of the Cornish boiler as compared with cylindrical boilers. These experiments will be made with boilers recently erected at Hetton Colliery, of improved construction. In conclusion, the writer expressed his thanks to Messrs. P. B. Hood, Wm. Armstrong, jr., and Emerson Bainbridge, for their careful attention in carrying out and tabulating the experiments.

ACCUMULATED HYDRAULIC POWER.

From "The Engineer."

We divided this subject into five heads in in our first article,* namely: (1) Cost of generating the power; (2) Loss by friction; (3) The cost of the machinery; (4) Convenience of application; and (5) Cost of maintenance. These heads we only treated generally and collectively in that article, as our object was to take a sort of "bird's-eye view" of the question; to be afterwards amplified in dealing with each point in detail. In dealing practically with complex problems it is impossible to adopt any system of division or classification which can be adhered to throughout. It is necessary at certain points to admit of a little overlapping of the divisions. We shall endeavor to keep the various divisions as distinct as may be, but we shall not hesitate to sacrifice mere classification to the more important considerations of clearness and practical convenience. Having thus far explained the "base of operations," we shall proceed to the discussion in detail of the "cost of generating the power."

Water pressure, such as we are discussing, can only be obtained by pumping into an accumulator, as the high pressure required exceeds that of any natural "head." As, for instance, in the case of the extensive sets of hydraulic cranes, hoists, &c., which have been introduced by Sir W. G. Arm-

* See Van N.'s Magazine, September, page 778.

strong & Co., the pressure most commonly adopted is 700 lbs. per square in.—a pressure corresponding to a head of about 1,600 ft. It is needless to observe that such a "head" as this is not obtainable either naturally or artificially in any of those localities where it would be commercially available. Even the lower pressures of 300 lbs., and 500 lbs., per square in., which have been adopted in our chief steel and iron works, would require respectivelyel evations of 700 ft. and 1,150 ft. These pressures, therefore, are only obtainable by the use of a loaded accumulator, and *à fortiori*, those higher pressures of two and three tons per in.—of which we shall treat in the course of our present inquiry—are necessarily so obtained.

We shall first consider those cases where a steam engine is employed to work the pumps, such being the rule, though it will be necessary to discuss some very important exceptions. With the question of the economic production of steam in the boiler we have not to deal, nor is it within our present purpose to discuss any points affecting the engine *per se;* though both these parts of the general apparatus must play a most important part in determining the question of absolute economy. Their selection lies, however, in the province of steam engineering.

It will be necessary, nevertheless, to consider the use of the steam in the engine as far as the same is affected by the construction of the hydraulic apparatus and the mode of conveying power from the engine to the pumps. The simplest way of looking at the work to be done is to consider the accumulation of the power merely in the light of a load raised a given height. The "head" of water which would correspond to the pressure per square in., is the measure of the height to which the load is to be raised, if such load be taken as the weight of the water pumped. If, on the other hand, the load on the accumulator be taken as the load to be raised, the distance through which the ram of the accumulator is raised is the measure of height. In the first case we have a small load raised to a great height; in the latter a larger load lifted through a less height. The first represents the amount of work by a theoretical expression, while the latter gives the actual state of the case. We shall have occasion to refer to each in its place, but we may call attention to the fact that the first is by far the more convenient, as the quantity of water pumped can be at once stated, or, in practice, ascertained by measurement; the total lift of the ram of the accumulator could, on the contrary, only be ascertained by complicated systems of addition and substraction, the actions of the machines keeping the ram in a constant state of upward and downward movement. We have got, then, a load, which is continuous, to be lifted to a given height. This load is, by its very nature, inelastic, and to raise it by an elastic force, as of steam, requires special adaptations to guard against waste of power. Clearly, the worst possible way to raise a load by steam power would be by the direct action of the steam, as, expansion being impossible, the steam must be discharged with the major portion of its energy undeveloped. Yet we have seen this done where an engine of the "direct-acting" class, with the steam piston-rod passed through the ends of the steam cylinder into two small hydraulic cylinders, was used for pumping into an accumulator at a pressure of about two tons per inch. Not only is there here the ruinous waste of steam, but as the speed of the steam piston cannot exceed that of the hydraulic pistons, a very large steam cylinder would be required to work a sufficient quantity of steam.

The speed of hydraulic pump plungers working at high pressures must be slow while a high speed of piston is advisable for steam engines, as reducing the cost and size of the engine and also facilitating expansion. The steam piston should run at from five to ten times the speed that the hydraulic plungers work at. It is therefore necessary that some sort of intermediate gearing should be used between the engines and the pumps; and also that provision should be made in the engine for a sufficient power of momentum to enable expansion to be fully carried out. There is a great advantage in the facility with which expansion can be carried out in engines employed in pumping into accumulators. No self-acting expansion gear worked from the governor is necessary; the load being constant, the cut-off may also be constant. Where engines are specially made for this work, it is advisable to use two cylinders connected to cranks set at right angles on one shaft. On this shaft should be a fly-wheel of a weight suited to the rate of the engine and the degree of its expansion. A second shaft should, by means of short, strong cranks, drive the hydraulic plungers, these cranks being opposite to each other. This second shaft is to be geared to the first by accurately made tooth gearings of the

proportions before mentioned. Such a construction as this is simple and in every way effective.*

It is requisite to provide an arrangement to the accumulator, such that when the ram reaches a certain height, the supply of steam to the pumping engine may be cut off; and also that when the ram falls a little below that point, the engine shall be retarded. The valves of the pumps and accumulators must be as straight in the passages as they can be made, and the pipes between them as free from bends—particularly sudden ones—as may be. The propelling of the water through bends and all confined passages is analogous to the drawing of a loaded carriage over stones or other impediments, and seriously increases the load against the engine. It is also a mistake to use pipes of small diameter, since there is a loss of power, not only in increasing the velocity of the current of water, but also in the greater surface presented by such pipes in proportion to their area. In employing long ranges of pipes it is better to put an accumulator at each end. The pumps should in all cases charge the accumulator by pipes distinct from the service pipes, which convey the water to the machines, as otherwise there will be continually opposing currents in the pipes when the machines are in use.

In some situations it may be found advantageous to work the pumps by means of a water-wheel or a turbine. The principles laid down in treating of the use of a steam engine for this purpose are applicable to such cases, except as regards the remarks about securing expansion. With the water-wheel or turbine the motor and the load are alike inelastic. From the shaft of a water-wheel the hydraulic pump plungers would be worked direct, while from a turbine a very great reduction of speed would be required; but in neither case would the addition of any "vehicle of momentum" be requisite.

We have spoken entirely of loaded, to the total exclusion of atmospheric accumulators, for the following reasons: In charging an atmospheric accumulator the diagram would show a curve of compression indicative of the power required for the work of charging. In using the pressure it would be impossible to obtain anything even approaching the reverse curve; therefore a serious waste of power must result. But this is not all. A very considerable amount of heat must be evolved which is totally lost; while there is yet further the weighty practical objection that the pressure continually diminishes as the machine operated moves. The inconvenience and loss thus caused are very serious, as a very great amount of power is used, and there is the least of it where the most is required. These shortcomings are in themselves sufficient to condemn the atmospheric accumulator; added to these is the very great risk of keeping air at so great a pressure. In most cases where atmospheric accumulators have been put up they have since been abandoned. The inducement to use them lay in their small first cost, and the absence of working parts to keep in repair.

There is one advantage appertaining to the atmospheric accumulator, namely, its causing little or no shock to the machines and fittings. With loaded accumulators as usually made, this shock is very injurious, and is only partially met by "relief" valves; in fact, the "relief" valve is usually fitted to ease the shock in stopping the machines by letting back the pressure against the accumulator. The load on the ram ought to be suspended on strong but lively springs, to take up the momentum of the load after a "fall." We have ourselves seen a load of twelve tons dropped 9 ft. with such quickness as to be practically equal to a free fall of that distance. For such a load to be suddenly stopped by an inelastic fluid like water must be eminently injurious to all the fittings and joints. Such injuries might be to a great extent guarded against by the adoption of efficient springs. In the annular "dished spring"—a simple steel washer—invented by Mr. F. A. Paget, C. E., and extensively applied to similar purposes on railways in France, we have just the thing required—a spring which can be placed round the rod by which the load is suspended, thus occupying little room, and capable of any amount of reduplication. The cheapness of these springs—which will do in Bessemer steel—is of importance as regards the question of cost which we are discussing.

Where machines are at long distances from the accumulator, it may be advisable in some cases to put "relief" plungers in small cylinders, with either weights or springs to absorb some part of any sudden shock occurring. In all cases where the

* Before saying too much about the simplicity of this engine, the author should look into the Worthington duplex pressure pump used in American steel works.—*Ed.*

work is heavy and intermittent, particularly if the power has to be conveyed long distances, its generation and conveyance by hydraulic apparatus will be a source of economy.

The economy of having a constant load against the engine has been already pointed out; and the economy of conveyance through long distances will be perceived from the fact that water pressure conveyed through upwards of two miles of pipes showed no perceptible loss of power. Shafting, on the other hand, if carried to any considerable length, absorbs a great deal of power to overcome its friction, entails a constant expense for lubrication, and is subject to considerable wear and tear. In conveying power by water, the distance makes but little difference in friction, there is no expense for lubrication, nor is there much wear and tear. Beyond this, pipes are cheaper to lay than shafting, can be laid where shafting cannot, and do not require protection from dust.

As against these sources of economy may be set the fact that, when not fully loaded, there is a proportionate loss of power with hydraulic machines, since the power used is always the maximum, whatever the load may be. It is questionable, however, whether the economic working of the prime mover does not more than counterbalance this; and while with shafting, machines must be started and stopped suddenly, with hydraulic pressure any graduation can be obtained. There is also a beautiful steadiness of motion—due to the want of elasticity in the water—which is of great value in most mechanical operations. We shall have a better opportunity of speaking of this latter advantage in dealing with the fourth division of our subject.

In connection with the cost of generating and accumulating the power, we would call attention to the feasibility, in many cases, of aiding the pumps by returning the water under pressure from a descending load. Take the case of a lift, where heavy wagons or cages have to be raised full and sent down empty. It would, in such a case, be possible to effect a considerable economy by leading the exhaust pipe direct to the pumps; as whatever might be the pressure exerted by the descending load, to that extent would the engine be relieved, and a corresponding economy effected. A case of this kind occurred at the Mersey Ironworks. A steam pressure of 45 lbs. was required to charge the accumulator when the water was discharged from the exhaust in the ordinary way. On changing the arrangement, so as to carry the exhaust water in confinement to the pumps, 25 lbs. sufficed. The merit of this arrangement is due to Mr. W. Clay. A somewhat similar arrangement has been for some years in use at Newport in Monmouthshire. In this case a small ram is driven back against the pressure of an accumulator by the descent of a box loaded with coal; such box being then discharged into the colliers' hold, is raised by the power accumulated by its descent, the difference of the weight when empty allowing for the friction of the apparatus. In some instances it is preferable to use a counterbalancing weight. These contrivances are, however, noticed here merely as means of attaining economy in the power. Their further discussion will come under the head of designing hydraulic apparatus.

We have advanced sufficient proof of the comparative economy of accumulated power for many purposes; its absolute cost will of course greatly depend on purely local causes, such as cost of fuel and labor.

FEED WATER.

ITS CHEMICAL AND PHYSICO-CHEMICAL EFFECTS.

F. A. Paget, Esq., C. E.

From "The Locomotive."

The wear and tear of a boiler which occurs in the form of corrosion, properly so-called, may be divided into two principal kinds: (1) internal and (2) external. The progress of both is necessarily intensified by the mere effects of temperature; each, however, has its strongly marked, distinct character—not merely as to position, but also as to origin and results.

A steam boiler is in the position of a vessel into which large volumes of water are continually forced; while the heat applied, driving off all volatilizable matter, leaves behind a concentrated solution with a chemical character dependent on that of unvolatilizable matters in the feed-water. The specific gravity of the substances found in the water naturally causes them to sink towards the bottom, at which part the solution is generally more concentrated, however much it may be stirred up by the ebullition. Mr. J. R. Napier lately stated that a piece of zinc "about 4 ft. long, by 3 in. broad, by $\frac{3}{16}$ in. thick, placed in a marine boiler for three weeks" to a depth of 18 in. in the water, showed a corrosion which rapidly de-

creased "up to the highest part, which, in the steam, appeared to be little affected."* This accounts for the fact that all boilers, even those internally fired, like locomotive boilers, have their plates most affected towards the bottom, and that internal corrosion always shows itself to a greater extent below the water line. The *bouilleur* of the form of boiler known as the French boiler, is also generally more affected than any other part. To resist this sort of slow action, it is clear that the more the bulk of metal the better, and it is for this reason that the bottom plates of most marine boilers are made thicker, while these same plates in locomotive boilers have to be often renewed. Any chemical or physico-chemical action of the kind is of course intensified by temperature, and this is one of the causes why externally fired boilers give way most, a little in front of the furnace. But the plates above the water line also get more or less corroded, and not merely with the usual character of rusting, but in that peculiar form known as pitting, which generally shows itself much more strongly marked below the water-line.

The presence of a concentrated solution of an acid or alkaline character, kept at a high temperature for years in contact with iron plates, would be sufficient to account for much corrosion. But the internal corrosion of steam boilers has many features of such a mysterious character, that no accredited explanation of its attendant phenomena has yet been put forward. In the first place, plates thus attacked show a number of irregular holes like a pock-marked human face, or like the small craters seen on the moon's surface.

The writer has also sometimes observed two or three little irregular excavations like this in a plate otherwise showing a large surface quite intact. Sometimes the plate is most pitted round a projecting bolt; at others, one plate will be perfectly sound, while that riveted to it will be almost eaten away, both having been the same time at work, and under, of course, apparently exactly similar conditions. With locomotive boilers this pitting has been ascribed to galvanic action between the brass tubes and the iron plates. But it is notoriously well known to locomotive superintendents, that boilers with iron tubes are often worse pitted than those which have run the same distance with brass tubes. Besides, all iron boilers, with or without brass, whether used for stationary, locomotive, or marine purposes, are subject to pitting.

An explanation which seems to meet all the circumstances of the case is the following: Mr. Mallet, in a report addressed to the British Association, some years ago, showed that wrought-iron and steel (blister-steel, probably) "consist of two or more different chemical compounds, coherent and interlaced, of which one is electro-negative to the other." In fact, ordinary wrought-iron, being also welded up from differently worked scrap, is far from being an electro-homogeneous body. In a boiler, the hot water, more or less saturated with chemical compounds, is the exciting liquid, and the electro-positive portions of the plates are thus quickly removed to a greater or less depth. This explanation meets most of the known circumstances with respect to pitting; it even, in a great measure, explains how plates above the level of the water, especially in marine boilers, get very rapidly corroded in portions, while another part of perhaps the same plate is scarcely affected. The concentrated water in a marine boiler is known to be generally acid. "Of all the salts contained in sea-water," says Farraday,* "the chloride of magnesium is that which acts most powerfully" on the plates. He shows that a cubic foot of sea-water contains 3.28 oz. of this salt; and, at the same time points to the danger of voltaic action in a boiler through the contact of copper and iron. In a smaller degree the contact of cast with wrought-iron, or between the different makes of wrought-iron in the same plate, or between contiguous plates, acts in the same way. It is not improbable that some hydro-chlorate acid is present in the steam of marine boilers. "Mr. J. C. Forster† has tested some of the condensed steam from the safety-valve casing, and from the cylinder-jacket of the Lancefield, and found both decidedly acid.‡ With an exciting liquid in the condensed steam, it is thus explicable how the plates of marine boilers often get corroded in a most capricious manner; while at the same time, the current of

* Institution of Engineers in Scotland, Session 1864–5.

* Fifth Report of the Committee of the House of Commons concerning the Holyhead Roads, p. 194.

† Institution of Engineers in Scotland, 1864-5. Introductory address, by Mr. J. R. Napier.

‡ When a solution of chloride of magnesium is evaporated nearly to dryness, the salt and the water are decomposed, magnesia and free hydro-chloric acid being formed; or $MgCl + HO = MgO + HCl$.

steam would create a certain amount of friction on the oxide, clearing it away to act on a fresh surface.

The crucial test of this explanation of pitting would be the observation of the absence of the phenomenon from plates of an electro-homogeneous character. This homogeneity could only be expected from fused metal, such as cast steel. Accordingly, while the writer was in Vienna a short time ago, he was assured by Mr. Haswell, the manager of the Staatsbahn Locomotive Works, that some locomotives made of cast steel plates, in 1859, for the Austrian Staatsbahn, had been working ever since without showing signs of pitting, though under similar conditions iron plates had severely suffered in this way. Pitting may thus be fairly defined as a form of corrosion localized to particular spots by voltaic action. It is also probably aggravated through the motion of the plate by mechanical action, and the expansions and contractions through alternations of temperature. All boilers are most pitted near the inlet for the feed-water, and with inside cylinder locomotive boilers there is generally more pitting at the smoke-box end—no doubt caused by the more or less racking action on these plates. A state of corrosion at particular spots would probably be kept up to a greater intensity by the incrustation being mechanically thrown off. With a quicker voltaic action, caused by any unusual intensity of the exciting liquid, the sides of the cavities in the plates would be sharper and less rounded off; as in the case of a boiler fed with mineral water from ironstone workings, which exploded last year at Aberaman, South Wales.

The fact that pitting occurs in marine boilers when distilled water from surface condensers is used, does not effect this explanation. Water distilled in this way, from whatever cause, after repeated boiling, is stated to carry the salinometer even higher than sea water, thus proving that it is not pure.* In the next place there is the absence of incrustation, which to some extent protects the plates of boilers from the chemical action of its contents. In this way the mechanical buckling of the plates—directly and indirectly causing the furrows we have spoken of—by continually clearing particular lines of surface from incrustation and oxide, reduces these particular spots, with respect to corrosion, to the condition of the plates of a boiler fed with water which deposits no incrustations. Corrosion will also act more rapidly at a furrow through mere increase and renewal of surface. To resist that form of internal corrosion specially known under the name of pitting, a maximum of electro-homogeneity is evidently required in all the component parts of the boiler.

While the action of internal corrosion, often very equally corrugating the plates over a large surface, as a rule scarcely, at any rate only gradually, affects their mechanical strength, external corrosion, being localized to particular spots, is of a much more dangerous character. The one is gradual and easily perceptible, while the other is rapid and insidious in its progress. Apart from accidental circumstances affecting the brickwork on which a stationary boiler is erected, or the outside of the bottoms of marine boilers, it is clear that external corrosion can only occur through leakage. When leakage takes place through a crack in the plate caused by mechanical action, or at a hole burnt out by heat, the effects of leakage are only secondary results, due to a primary cause which of itself may cause the stoppage of the steam generator. But a leakage at a joint may in itself gradually cause the destruction of the boiler. Here we see another reason that the character of a boiler, not merely as to ultimate strength, but also as to wear and tear, intimately depends upon the form of its joints. It is often noticeable that very good lap-joints, even when tested under hydraulic pressure up to only 50 per cent above the working load, sweat more or less. The tendency of the internal pressure to form a correct circle bears indirectly on these joints, causing them to open, more or less, and to leak, in spite of the caulking. Mr. Robert Galloway, C. E., who, as an engineer surveyor of long standing of the Board of Trade, has probably made more than three thousand careful inspections of marine boilers, states that he has often noticed a furrow or channel on the outside of the joint, running parallel to the outside overlap for some distance, and evidently caused by leakage. Along the water line, condensed water will act on the joints, while below it the concentrated contents of the boiler will come into chemical action. A leakage in a marine boiler often eats away a plate within a year. In some cases a jet

* Institution of Mechanical Engineers, 1863. Discussion on Mr. James Jack's paper "On the Effects of Surface Condensers on Steam Boilers."

of hot water from a leakage has a frictional action; in fact, even with such an incorrodible and hard substance as glass, an effect like this has been perceived, and a slight leakage continued during several days sometimes produces a noticeable furrow on a glass gauge tube. With sulphurous fuel, a powerful chemical action will come into play on the plates. One volume of water takes up about thirty volumes of sulphurous acid gas; and these sulphurous fumes of the fuel, coming into contact with the water from a leakage, will be more or less absorbed. An acid solution like this must quickly eat away the plate. It is certain that a leakage acts much quicker on a boiler fired with sulphurous fuel than on one fired with wood. M. G. Adolphe Hirn has observed a plate, nearly seven-eighths thick, to be pierced, in the course of time, as with a drill, by means of a little jet which struck it after passing through a current of hot coal smoke.*

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf.
Translated from "Annales du Génie Civil."
(Concluded from page 805.)

It is apparent that, among the causes of the inferiority of the surface condenser, incrustation is one of the most efficient. It will therefore be proper to examine whether there be any method of preventing, or, at least, of diminishing it.

1st. The condensing water, whether derived from wells, from rivers, or from the sea, always contains incrusting salts, such as bicarbonate of lime, in the case of fresh water, and bicarbonate of lime and magnesia in salt water. These salts, losing a portion of their carbonic acid, will deposit neutral carbonates upon *the exterior face* of the condenser, unless they are converted into soluble salts by the addition of sulphuric or hydrochloric acid. But as sea-water, and most fresh water, contains more than .0002 of carbonates, the use of these acids, however cheap they may be, would be very expensive.

2d. As to *the interior surface*, nothing can prevent its incrustation. Indeed, supposing even that the feed water be perfectly distilled, and contain no salt in solution, it will still hold in suspension insoluble matters, resulting from the boiler cements, from the wear of sliding surfaces, and especially from the oxide of iron, which is produced abundantly. The steam, carrying a certain quantity of these substances in a state of minute division, deposits them upon the condensing surface, where they form a crust, which is much aggravated by the lubricants, also introduced by the steam. It would be hopeless attempting to remedy these difficulties by filtering the water after issuing from the condenser, and before injection; this would be merely a palliative, since incrusting matter is constantly forming in the boilers, in the cylinder, and in the steam pipes.

3d. Finally, these substances, supplied by the various members, are by no means the only ones which contribute to the incrustation of the internal face. Practically, it is impossible to make a surface condenser perfectly tight. The extent of surface required necessitates the use of very many small flues (4,000 to 5,000 for an engine of 350 horse-power). In the great number of joints occasioned by these flues, owing to the frequent alternations of temperature, there will always be some leaks, through which the exterior water will be forced by atmospheric pressure. The water in the boiler thus becomes rapidly charged with incrusting matter, which is deposited in crystals of carbonate and sulphate of lime, and, in the case of sea water, of free magnesia.

It may also be remarked that with the cold water entering through imperfect joints, are introduced the gases which it holds in solution, whose presence in the flues of the condenser neutralizes the effect of the vacuum.

4th. The incrustation of the surface condenser is therefore inevitable. But will it be practicable to diminish it by a systematic method of cleaning? In a previous paper on the incrustation of boilers I indicated, in reference to a structure having a close resemblance to the surface condenser, a method of cleaning, which might be applied here. It consists in providing an alternate condenser, thus admitting of the rest of one of them which would allow the application to the exterior of the flues of a weak solution of hydrochloric acid, in order to dissolve the carbonates, and to the interior, of a concentrated boiling solution of carbonate of potash, in order to break down the thick scale and facilitate its removal by means of the ordinary flue scraper.

Having established the general theory of condensation, and deduced the superiority of the injecting over the surface condenser, and having enhanced this superiority by indicating the improvements of which it is

* Bulletin de la Société Industrielle de Mulhouse, 1861, p. 558.

susceptible, it remains to demonstrate that it is applicable to marine engines, as well as to other condensing engines, and to describe the method of its application.

The obstacle in the way of condensation by injection in marine engines working at high pressures is not in the principle of condensation, but in the water-supply of the boilers. By the mere elevation of temperature the feed water precipitates its calcareous salts, even without the added effect of progressive concentration, and deposits them in the boiler, partly in the form of scale, which diminishes the transmission of heat, and partly in the form of small crystals, which gather upon the heating surfaces. When the pressure does not exceed 1.5 to 2 atmospheres, or the temperature does not exceed 121°, the point at which sea-water dissolves twice the quantity of sulphate of lime which it contains naturally, blowing out may be resorted to at suitable intervals. This will retard, but will not wholly prevent incrustation. But even this resource is no longer available when the pressure rises to 2.4 atmospheres and the temperature to 127°, since, at that point, the water begins to deposit its sulphate as soon as it enters the boiler.

It is essential, then, to obtain a feed water free, or nearly so, from calcareous salts, and for this purpose the surface condenser was devised as a simple method of obtaining distilled water, which was most reasonably supposed to be eminently suited to boiler supply.

Generally speaking, then, the function of the condenser may be said to consist of two distinct acts: 1st. Transferring the heat of the steam to cold water, thereby condensing the former. 2d. Eliminating from the engine all of this heat, except so much as is returned to it in the feed water. In both forms of the condenser these two acts are performed *simultaneously*, and in the interval of time occupied by two strokes of the piston. But the general performance of the engine requires only that the first act should be accomplished rigidly within the time just mentioned; the other may be effected at leisure with the sole condition, that it be done in such a manner as not to impede the condenser. This state of facts allows the practical application of the *monohydric* principle of condensation, which consists in ejecting into the condenser the same water, continuously and repeatedly, which will be non-incrusting, if previously deprived of its calcareous salts, and in refrigerating it each time it passes the condenser, without intermixture with the cooling water. It is clear that if refrigeration is made a separate operation, entirely independent of the condenser, we shall have all the advantages of injection and a non-incrusting feed water. This principle is not new. It has already been applied to pumping engines in mines where the water is acid and corrosive. I have myself given an application of it in a memoir on incrustation, with the plan of a refrigerator for effecting the repeated cooling of the injected water. I propose to employ it as an accessory of an engine, provided with an injecting condenser, and for a detailed description of it I beg leave to refer to the memoir in the *Annales des Mines* (September and October, 1854). The following is a brief description of the refrigerator:

"The water drawn from the condenser is raised by a pump to a reservoir placed at an elevation of several meters, and underneath this reservoir is located the refrigerator, composed of vertical copper tubes, surrounded by a cylindrical copper shell. The warm water descends from the reservoir through the tubes, which are immersed in the cold water, which is constantly renewed by a current moving from below upwards, i. e., in a direction contrary to that of condenser water."

It is plain that the apparatus employed in the English practice as a surface condenser might be used as a refrigerator, requiring only to be placed in such a manner that the tubes be vertical instead of horizontal, or slightly inclined. The vertical position is essential to a regular and perfect method of refrigeration, since it exposes the descending water to colder surfaces of refrigerating water the lower it descends.

"To avoid the incrustation of the interior surface caused by the lubricants there may be occasionally introduced into the tubes a hot alkaline solution, which will saponify the crust. For cleaning the exterior surfaces of the tubes a process is adopted analogous to the preceding. It consists in introducing into the cold water space a weak solution of hydrochloric acid, which will dissolve the carbonates. By means of a system of suitably arranged valves both operations may be effected promptly, without labor and without deranging the action of the engine."

As to the details of construction, especially the setting of the tubes, their diameter, etc., one could not do better than follow the established rules of English practice for surface condensers.

Although I see no reason to doubt the efficiency and success of the monohydric system of condensation, I think it might be well to examine some particulars of the process. The quantity of heat to be withdrawn from the apparatus, for each stroke of the piston, is $q\ (650—\theta)$. This, obviously enough, is the same quantity which is carried off by the cold water, which circulates around the exteriors of the tubes of the English surface condensers, and, finally, is also the same as that which should be removed from the condensing water by the refrigeration. In the condensers the transmission of heat takes place by virtue of the difference of temperature expressed by $(a—b)$, and $a = \frac{\Theta—\theta}{2}$, which is greater than θ. In the refrigerator this transmission takes place by virtue of $(\theta—b)$. This is a disadvantage, as it reduces the rapidity of the cooling; but it will be largely compensated by the absence of air in the tubes, by the regularity of the process, and by the diminution of scale. In brief, the ratio of one sq. meter per horse power, adopted in England for surface condensers, will be more than sufficient for the refrigerator. Were it otherwise it would be easy to increase this surface until the desired effect be obtained. With respect to leakage in the joints, which has been discussed with reference to the surface condenser, we should find the same difficulty recurring in the refrigerator, but only in an immaterial degree; since, on the one hand, the pipes of the refrigerator would be subjected to much smaller changes of temperature, and on the other, there would be no difference between the interior and exterior pressures. Again, the intromission of gas, which is a serious matter in the surface condenser, is of no particular consequence in the refrigerator.

The presence of a small quantity of sea water in the feed water, far from being an evil, will be beneficial. It would cause a slight incrustation, which would protect the plates against oxydation and the deposit of grease. This would add to the conductibility of the metal, provided the scale remain within the limits previously described.

It has been determined in England that, in engines having surface condensers, there is a corrosion due to the grease brought into the boilers by the feed water. This substance accumulates constantly, producing numerous cavities in the plates, thus shortening the life of the boilers and exposing them to the danger of explosion. The English remedy this difficulty by introducing into the feed water a small quantity of sea-water, which gives rise to a slight protective incrustation of the metal. To this precaution some people add another, viz: omitting to lubricate the piston and slide valve, thus extirpating the evil at its source. This mode of procedure is undoubtedly a great sacrifice. Still, it may be necessary in surface condensation, but it is not so in the monohydric system—a consideration strongly in favor of the latter.

It might be feared that the increase of weight and bulk required by the refrigerator would be a difficulty. But, it will be remembered that the refrigerator is merely a surface condenser with a change of function, and the English have found means of placing in vessels of all sizes surface condensers having more than a square meter of surface per horse power. Their experience for the last four years or more ought to reassure us on that point. We may close this paper with a statement of the following general conclusions: There is great advantage in using steam at high pressures in marine engines. Two methods of its application seem to present themselves: 1st, the surface condenser; 2d, the injecting condenser on the monohydric principle. The injecting condenser is, on principle, much superior to the surface condenser; this superiority is expressed by the ratio of the parts of the resisting work, due to the retardation of condensation, in each apparatus respectively,

$$\frac{Tci—p\ S\ L}{Tcs—f\ S\ L} < \frac{\sigma^2\ R_1^2}{\Sigma^2\ R_1^2}$$

R_1 and σ being always very small as compared with R_1 and Σ.

By the injecting system it is possible to reduce the resisting work of the back pressure to $\frac{1}{4}$ of what it is in the actual injecting condenser, supposing the most favorable conditions; conditions which in the surface condenser are ideal, and can never be realized by reason of the friction of steam in the tubes, the presence of air and of incrustations, which are formed within and without.

The surface condenser consequently is subject to perturbations which may deteriorate considerably, and even counterbalance the advantages of high pressure. The injecting condenser will realize these advantages simply and surely. Hence there is good ground for abandoning surface condensation and employing injecting condensation on the monohydric principle.

AIR IN ILLUMINATING GAS.

From a paper in the "American Journal of Science and Art," "On the effect of Atmospheric Air when mixed with Gas in reducing its illuminating power," by B. SILLIMAN and HENRY WURTZ.

The data given in this article were obtained during an investigation of the Hydrocarbon Gas Process by the "*Gwynne-Harris*," or "*American System*," some notice of the results of which we propose to publish in a future number of this Journal. In the course of this investigation it became important to measure exactly the effect of atmospheric air in reducing the illuminating power of gas. Owing to a mechanical defect in the apparatus connected with the exhauster, it was found that a variable quantity of air had for some time found its way into the gas holder, the influence of which, in diminishing the brilliancy of combustion, was sufficiently conspicuous before the cause was ascertained. The only experiments on this subject known to us when its study was undertaken by us, were those of Messrs. Audouin and Bérard* (also quoted in the American Meter Co's. Pocket Almanac). By these results the ratio of loss in illuminating power by the addition of each one per cent of air appeared to us so enormous, that we were desirous of confirming them. Subsequently we became acquainted with an important paper on this subject by Mr. Carl Schultz,† the main points of which are reproduced in this article; as they appear to have escaped attention, the author having modestly given us only his initials, and the journal in which they appeared being almost inaccessible to scientific readers.

In conducting this research we soon found that the attempt to introduce, by measure, a given volume of air into the gas holders connected with the photometric apparatus, was attended with many sources of error, and that the requisite accuracy could be obtained only by the eudiometrical analysis of each successive mixture.* The apparatus employed consisted of two gas holders of ten cubic feet capacity each, connected in such a manner that each could be used independently, or the contents of one transferred to the other and back again to secure a complete admixture of the contents. The air was introduced by opening a stop-cock connected with the interior, and adding weights to the counterpoise, measuring the influx by a centissimal scale of equal parts attached to the drum of each holder. This rude admeasurement was controlled by an analysis of each mixture. This required also the prior analysis of the street gas on each occasion, columns 3, 4 and 5, of the accompanying Table I, show the results of these mixtures as made known by the eudiometer. The illuminating power of each sample was determined by the Bunsen photometer on

* Ann. de Ch. et Phys., 3d series, vol. lxv, p. 423, 1862.

† American Gaslight Journal, Aug. 1, 1860, p. 41.

* Our labors in this research have been greatly aided by the facilities courteously extended to us by the officers of the Manhattan Gas-Light Company, in New York, who with great liberality placed at our disposal their well appointed experimental laboratory and apparatus at their Eighteenth St. Station.

TABLE I.

DATES.	DENSITIES.		COMPOSITION.			ILLUMINATING POWER.						
Gas of Manhattan Co., N. Y., 18th Street Station, from street mains.	Density of street gas.	Density after air was added.	Air found by analysis in street gas, in 100 volumes.	Air found by analysis after the addition.	Volumes of air added.	Candle power of street gas before addition of air.	Candle power after addition of air.	Candle power of gas alone, air being deducted.	Loss of candle power by air added.	Percentage loss of candle power.	Ratio of loss in candle power in percentage volumes.	Loss of candle power for each one per cent
1860												
March 17.....	401	409	1.96	3.01	1.05	15.12	14.20	14.96	.92	6.08	5.79	.723
" 18.....	392	405	3.15	4.97	1.82	14.67	13.27	14.40	1.40	9.54	5.24	.511
" 23.....	401	424	1.50	3.75	2.25	14.71	12.96	14.37	1.75	11.82	5.25	.582
" 19.....	387	419	1.61	4.61	3.00	14.81	12.49	14.46	2.32	15.69	5.23	.656
" 19.....	387	433	1.61	6.54	4.95	14.81	11.28	13.76	3.53	23.83	4.83	.501
" 19.....	387	467	1.61	13.32	11.71	14.81	8.67	13.07	6.14	41.46	3.54	.419
" 20.....	387	490	1.61	17.79	16.18	14.81	6.29	12.41	8.52	57.53	3.55	.378
" 23.....	403	525	1.12	21.88	20.76	15.09	4.09	11.96	11.00	72.90	3.50	.377
" 20.....	401	551.5	1.61	26.29	24.68	14.11	2.18	10.52	11.93	84.55	3.42	.380
(Gas burned in a 5-ft. 15-hole standard Argand)	1	2	3	4	5	6	7	8	9	10	11	12

the average of fifteen successive observations of one minute each, with the usual corrections. Columns 6 and 7 give these results, and in columns 1 and 2 will be found the corresponding densities determined by diffusion.

Since the air added in each case is rendered *as gas* by the meter during the photometric measurement, it is important to determine the illuminating power of the gas alone after deducting the known volume of air present. The results of these calculations are given in column 8. In columns 9 and 10, the loss of illuminating power is given; in 8, in terms of the candle power lost for each admixture, and in 9, this loss is stated as a percentage. The ratio of loss of illuminating power in percentage volumes of gas and air is given in column 11, and in column 12 is the loss of power corresponding to each one per cent of air added.

The results of the analyses and photometric measurements are more conspicuously seen in the curve projected from columns 5 and 10 of the table upon the annexed diagram, on which the vertical and horizontal scales are as 1 : 3.

The following inferences depend upon the data herein given, viz:

1st. For any quantity of air, less than 5 per cent, mixed with gas, the loss in candle power due to the addition of each 1 per cent is a little over $\frac{6}{10}$ths of a candle (.611 exactly); above that quantity the ratio of loss falls to $\frac{1}{2}$ a candle power for each additional 1 per cent up to about 12 per cent of air; above which, up to 25 per cent, the loss in illuminating power is as shown by column 12 of the table, nearly $\frac{4}{10}$ths of a candle for each 1 per cent of air added to the gas. In column 11 of Table I, the ratio of loss in candle power is given in percentages for the several volumes, while in column 10 the destructive effect of air upon the illuminating power of gas is most conspicuously exhibited, 12 per cent of air destroying over 40 per cent of the illuminating power. In the diagram this loss of power is represented by the numerals in the right hand column, which are inverse to those in column 10, and stand with the maximum intensity = 100.

2d. With less than $\frac{1}{4}$ of atmospheric air, not quite 15 per cent of the total illuminating power remains; and with between 30 per cent and 40 per cent air, it totally disappears.

Now, during December and January the hydro-carbon gas made at Fair Haven had often as much as 12 per cent of air in it; during the month of February the air, by analysis, averaged nearly 9 per cent; while in March, after the separation of the pump from the exhaustion apparatus, the air was reduced at times to nearly nothing. By column 3 of the table it will be observed that the air found by analysis in the street gas, at the Eighteenth Street Station of the Manhattan Gas-Light Co., New York, averaged nearly 2 per cent, and the New Haven city gas contained about the same quantity. We allow, therefore, this quantity (2 per cent) as a normal amount of air in street gas; and, consequently, in the journal of the daily operations with the hydro-carbon process at Fair Haven,* these corrections have been applied; giving in two columns the "corrected candle power," by the addition of the ratio determined in our Manhattan experiments, and the "corrected volume," or yield per pound of coals carbonized, air being deducted." It is obvious that the records of the station meter give the contaminating air as gas, and without the correction thus obtained, the apparent yield is too great.

In large gas-works the liability to contamination by air accidentally introduced from various causes, diminishes in proportion to the total make of gas, and an amount of air which, when diffused in a very large volume of gas, becomes insignificant, if confined to ten or fifteen thousand feet daily product, will become a most serious injury to its illuminating power. This cause of deterioration in gas has been overlooked almost entirely by gas engineers; but in all small gas-works it deserves special attention, and we have no doubt that the low illuminating power, too often obtained in such works, is largely due to this cause.

Results of Messrs. Audouin and Bérard. —We have already alluded to these results, obtained by Messrs. A. and B., which form part of an important memoir published in 1860, under authority of the French Government "upon the various burners employed in gas lighting, and researches on the best conditions for the combustion of gas." Their table, which we append for the sake of comparison, shows "a considerably high-

* *The Hydro-carbon Gas Process.* Report of working results on a large scale under the Gwynne-Harris Patents, Nov., 1868, to May, 1869. by Benjamin Silliman, M. A., M. D., and Henry Wurtz, M. A., N. Y. 8vo, p. 126, printed for private distribution.

er ratio of loss than we have obtained, being rather more than six per cent loss for each one per cent of air added to the gas, reaching a total loss of 80 per cent with 15 per cent of air added; while we obtain 57.53 per cent loss with 16 per cent; and 93 per cent loss with 20 per cent air, while with the latter volume of air added, we get 72.-90 per cent loss. These differences may be accounted for by the French trials being made upon a gas of not more than 12 candles' power, our trials being made on a gas averaging nearly 15 candles. Also, by the fact that in the French experiments the gas was burned from a batswing burner, ours from a standard Argand.

In the experiments of Messrs. Audouin and Bérard, two gas holders of equal capacity were filled, one with standard gas, and the other with the same gas mixed with 1, 2, 3, etc., per cent of air. Each fed a burner of the second class, regulated to a consumption of 140 liters of gas per hour. The illuminating power of the two were compared by making that of the pure gas equal unity. The results are given in the following table, where each figure gives the mean of 6 or 8 concordant observations.

TABLE II.

Showing the results of mixture of air with gas, by Messrs. Audouin and Bérard.

Common Gas.			Gas mingled with Air.				
Intensity.	Size of flame.		Quantity of air per 100.	Intensity.	Intensity of loss.	Size of flame.	
	Height	Breadth				Height.	Breadth.
	mm.	mm.				mm.	mm.
100.....	49	92	1	.94	6	43	102
100.....	48	92	2	.89	11	42	100
100.....	49	93	3	.82	18	42	97
100.....	48	94	4	.74	26	42	91
100.....	46	94	5	.67	33	42	96
100.....	45	93	6	.56	44	41	95
100.....	48	93	7	.47	53	40	94
100.....	48	93	8	.42	58	39	94
100.....	46	94	9	.36	64	39	93
100.....	47	93	10	.33	67	38	89
100.....	46	93	15	.20	80	35	86
100.....	45	92	20	.07	93	33	86
100.....	45	92	30	.02	98	23	79
100.....	45	92	40	01	99	21	60
100.....	45	92	45	....	100	18	47
100.....	45	92	50	....	100	12	24

By this table it appears that the introduction of 6 to 7 per 100 of air, suffices to diminish the intensity by one half, and a mixture of 20 of air with 80 of gas leaves almost no illumination. Unfortunately Messrs. A. and B. do not record the actual illuminating power of their standard gas, which, however, we are led to believe cannot be more than 12 candles of the English and American standard.

We have already alluded to the experiments of Mr. Carl Schultz, and annex below a summary of his results.

Mr. Schultz concludes from his experiments, that the loss of illuminating power due to the addition of air to gas, is about one-half of one candle for each one per cent of air added. He makes the very remarkable observation, that, within limits, the addition of air to *very rich* cannel gas, up to 12 per cent of air, was followed by no loss of illuminating power, but, on the contrary, by a small gain. Thus, boghead cannel gas, giving for 88 per cent gas an illuminating power of 27.47 candles, or for 100 per cent gas 31.32 candles, with 12 per cent of air, gave 28.29 candles, showing that 12 per cent of atmospheric air had increased the illuminating power of the flame by .82 candles. These results are obtained only by the use of an Argand burner. By substituting an intensity burner for the Argand, the results obtained with gas from boghead conform to the rule of half a candle loss for each one per cent of air. (Rev. Mr. Bowditch also states generally, that "impurities are far less destructive of light in Argand burners.")

Mr. Schultz sums up his results in the following propositions:

1st. When coal gas is mixed with atmospheric air, its illuminating power for all 5 ft. burners is reduced in the proportion of half a standard candle to every 1 per cent of air present, except in case of very rich gas burned with a 15 hole Argand.

2d. One cubic foot of atmospheric air will destroy an amount of light equal to 10 English standard candles, during one hour.

3d. This loss being constant, the percentage of aggregate loss will vary with the illuminating power of the gas used.

While our results confirm in general those of Mr. Schultz, in 1860, and of Messrs. Audouin and Bérard, in 1862; it is obvious that the ratio of loss, with equal increments of air added to a 15-candle gas, is by no means constant. The difficulty of obtaining exact results, by the method of mixture of measured volumes is so considerable, especially with quantities below 10 per ct., that the only safe control of the results is that which is obtained by eudiometrical analysis of the several mixtures tested, as was done by us in all cases both before and

after the addition of air. It is obvious that the surprising loss of intensity by the addition to illuminating gas of small percentages of air must be owing not merely to the interior combustion due to the presence of oxygen, but still more, probably, to the associated nitrogen, which acts not only as a diluent, or deductive quantity, but its specific heat is an actual *divisory* function in diminishing the flame temperature. The interesting observation, first made by Mr. Schultz, that in very rich cannel gas there is actually an increase of intensity within certain limits due to the presence of oxygen, suggests another series of experiments with successive additions of oxygen to a gas of high illuminating power, which we propose to undertake at our early convenience, as also another series upon mixtures of progressive quantities of carbonic acid.

NOTE.—*Erdmann's Photometer* ("*Gasprüfer*") depends on the use of air to destroy the illuminating power of gas. Elster has employed this instrument in a series of researches, undertaken to determine the theoretical illuminating power of different materials ("Journal für Gasbeleuchtung," Munich, 1862, p. 384, *et seq.*) After removing the illuminants by sulphuric acid, he found that ordinary illuminating coal-gas required 150 volumes of air to destroy completely the yellow flame of 100 volumes of gas. If the amount of light obtained by the addition of one per cent of olefiant gas to the decarbureted gas employed in a definite burner, is called *one candle*, it was found necessary to add 6.5 per cent of air to destroy the illuminating power of this gas containing one per cent of olefiant gas, or to destroy one candle power. As a like quantity of carbon, carried to a white heat, produces always, in a gas burning from the same burner, the same quantity of light, and it requires the same quantity of air to transform it into carbonic acid, we may regard an ordinary 12-candle gas as a mixture of an unknown non-luminous gas, holding in suspension during combustion a quantity of white-hot carbon, equivalent to 12 per cent of olefiant gas, and requiring, consequently, a quantity of air equal to 210 volumes for 100 volumes of gas ($88 \times 1.5 + 12 \times 6.5 = 210$). Each additional candle power requires an addition of 5 volumes of air, as the constant indicated by these results of Elster. [*Translated from Schilling, French Edition of* 1868.]

In the use of the Erdmann apparatus, it is found that the volume of air required completely to destroy the illuminating power of coal-gas ranges from 188 to 245 volumes per 100 volumes of gas, varying with its richness.

These results, it will be observed, harmonize in a satisfactory manner with those obtained by us, as embodied in Table I.

Every chemist will at once recur, also, to the action of air upon gas in the Bunsen burner, in constant use in all laboratories provided with gas—an instrument identical in principle with the *Gasprüfer* of Erdmann.

STEEL RAILS.—Certain tests of the ductility of steel rails are about to be instituted at the works of the New York Central Railway, at West Albany. We will try to give our readers the result in our next issue.

THE MECHANICAL VENTILATION OF MINES.

By Mr. WILLIAM COCHRANE.

Abstract of a paper read before the Institution of Mechanical Engineers at Newcastle.

It must be admitted that in the great advance which has been made in the development of mining enterprise, and looking to the future requirements of our local coal fields, adequate ventilation is not inferior in importance to any of the problems which the mining engineer has to solve. The earliest records of mining make us acquainted with the readiest mode of ventilation, no provision beyond the natural conditions being adopted; and so long as mines were only worked to a very limited extent by levels or "adits," and if by shafts, of very small depth, the natural system was found to answer all requirements; only there was this disadvantage — that, with thermometrical variations, the determination of the current of air was dependent on the average temperature of the mine being above or below that of the external atmosphere, a condition constantly varying and interchaning throughout the year, and therefore not permitting any certainty of action in the direction or quantity of air which can be used for ventilating the mines. This system is still used in mines of limited extent, and where, from the nature of the mine, very small resistances are offered to the current of air circulating. In some cases, under these conditions, as in the Staffordshire "thick coal" mines, the determination of the air into a particular course is often ensured by placing a fire lamp in the upcast shaft. Such a contrivance, however, can only produce a very small effect, and is therefore of limited application. On a larger scale, however, this principle has formed the most generally adopted system of mine ventilation in this country, namely, that of the furnace. This paper then described the system now most generally in use, and went on—Much discussion has arisen as to the best system of furnaces and the most economical mode of feeding them with air. The following were the results of some recent experiments that had been made at different collieries in the northern coal fields under various conditions and depths of shafts, extent of workings and thickness of the seams of coal, and were reduced for the purpose of comparison to the duty that one pound of coal consumed, effected per horse power on the air circulated in the mine, the pressure being indicated by a

water gauge placed in the mine, and therefore representing only the work done in overcoming the friction down to the mine, and exclusive of the work required to overcome the friction resistance of the two shafts. The general result of the experiments was that that duty varied from 37 lbs. to 101 lbs. of coal per horse power on the air taken upon currents of air ranging from 40,000 to 120,000 cubic feet per minute. Depth of shaft, it is said, is the most important consideration for the efficient application of a furnace. There are other conditions, however, which it is necessary to secure, namely: that the shaft be dry, and that it be lined with a good heat-retaining material. It is considered a fair estimate of the economic value of the average conditions in which furnaces are worked that only five degrees of the heat due to the combustion of the coal are utilized. There are many objections, besides the small useful effects in the use of the furnace, which cannot be overcome, and which form a constant source of cost attendant upon it, namely: the necessity of cleaning the flues and the consequent suspension of the active ventilation of the mine; the inconvenience, and in some cases the impossibility, of using a shaft highly heated and often full of smoke, for any other purpose than as a ventilating shaft, and the serious damage done to cast-iron tubing, timber, pumps or wire ropes, where winding is carried on in the up-cast shaft by the products of combustion, especially where the shaft is damp. If the conditions are unfavorable for the use of a furnace—such as shallow shafts and heavy resistances to be overcome—the furnace is then quite unable to compete with a good mechanical ventilation for economical effect. The limit of the furnace as a ventilating power is soon reached where the resistances offered by a mine are heavy; and this objection materially led to the adoption of other means to meet the conditions under which the furnace would fail to afford a sufficient ventilation. Machines for blowing fresh air into or exhausing the foul air from mines were adopted in the very earliest times, especially abroad, where the conditions of the seams are such as required more efficient means than the furnaces supplied. Hence it is that mechanical ventilators are very numerous abroad, while in this country, until very recently, they were quite exceptional. In a table compiled by Mr. J. J. Atkinson, Government Inspector for the Durham coal field, has been shown the depth at which furnaces are estimated to be equal to ventilating machines in point of economy of fuel, assuming that the sources of loss are of the same extent in each case; that is, the loss of fuel in furnaces by cooling in the upcast, and in ventilating machines the power expended in overcoming the useless resistances, and that the ventilating machines utilized 60 per cent of the engine power. The general result is that the minimum depth at which the economy by the two plans is equal is 960 yards, with an average upcast temperature of 100° Fahr., and a depth of 1,130 yards with 200° Fahr. temperature, estimating a consumption of 8 lbs. of coal per hour per indicated horse power of the engine. A recent calculation by M. Guibal, of Mons, deduces the following comparisons: that if a furnace in a 12 ft. shaft, 400 yards deep, circulate 53,000 cubic feet of air per minute under the total resistances represented by 3⅛ in. water gauge, and an average excess of upcast temperature of 108° above the downcast, with a duty of 31 lbs. of coal per horse power in air estimated upon the total resistances—a mechanical ventilator utilizing 60 per cent of the power employed would, under the same conditions, have a duty of 11 lbs. of coal per horse power in the air, being a saving of 64 per cent. At a depth of 550 yards to circulate the same volume, the duty of the furnace being 22 lbs. of coal, that of the mechanical ventilator would be 11 lbs., being a saving of 50 per cent. The paper then classified the mechanical ventilators which had been used under two heads—first, those working by centrifugal action; and, second, those working as pumps. Of those of the first class, one had been described at the last meeting—the Guibal ventilator, at Crudley Colliery, Staffordshire. The largest example, it went on, of that class erected in this country will be seen at the Thrislington Colliery. It is 36 ft. diameter and 12 ft. in breadth, driven by a horizontal cylinder 30 in. diameter and 30 in. stroke. This ventilator has only been recently erected, and is not yet ventilating any large extent of working, but some experiments have been made with it, from which the following results have been obtained. The regulating shutter was not properly adjusted so as to give the best results of working, and the drift to the upcast shaft was too small for accurately increasing the current of air, amounting to 80,000 cubic feet per minute. With 54 revolutions per minute a water gauge of 2½ in. was

maintained at the inlet; with 70 revolutions a water guage of 4½ in., and with 80 revolutions a water guage 6¼ in. After giving the results of other Guibal ventilators in operation, the paper continues: In order to make a fair comparison of the Guibal ventilator with the furnace, the following case of the Pelton Colliery, Durham, is given, as it is the only one where the data have been accurately ascertainable respecting the replacing of the furnace by this mechanical invention. In this case the duty obtained by the furnace was 102 lbs. of coal per hour per horse power in the air estimated, on the water gauge of $\frac{1}{10}$ in. indicated in the mine, and a current of air of 35,000 cubic feet per minute; and the duty was reduced by the ventilator to 20 lbs. per hour per horse power with a current of 54,000 cubic feet, and a water gauge of 2 in. indicates in the same position. This shows a saving of fuel by the adoption of the Guibal ventilator in place of the furnace, amounting to 80 per cent. The class of ventilators to which the Guibal belongs is that of centrifugal action, and in the same class may be mentioned the Biram, Nasmyth, Brunton, Rammell and Waddell ventilators. [Diagrams of the Nasmyth, Rammell and Waddell ventilators were exhibited.] A Biram ventilator (similar in principle to the Nasmyth, with the exception of the vanes being inclined to the radius) the writer has experimented upon at Tursdale Colliery, Durham, and found that only 12½ per cent was utilized of the gross power supplied from the steam boilers; and from experience with other open running fans, he considers that percentage cannot be materially exceeded with any form of open fan without a casing. A Waddel ventilator, recently erected at Pelton Colliery, utilizes only 39 per cent of the power applied; and a Rammell, at Framwellgate Moor Colliery, does not exceed 40 per cent of utilized power. The Guibal utilizes 60 per cent of the power applied. Except the Guibal, all the other ventilators of this type discharge throughout the entire circumference; but that this is a defect can be inferred from the fact that if such a fan running open have the access of air into its center stopped, great power will still be required to make it revolve, though no useful work is done. The useless work done upon the external air in this case is done to a diminution of useful effect, when the fan is exhausting air supplied at its center from any mine drift or passage. It was anticipated that the Waddell ventilator would obviate this defect by arranging the air passages through fans of a gradually decreasing section from the center to the circumference, so that the velocity of rotation at any point multiplied by the sectional area of passage at that point should be constant, thus filling up the fan with the issuing air, and preventing the possibility of re-entries. In this case the re-entries cannot be seen as in the Biram, where the eddies of air all round the circumference are easily distinguished, but that they do evidently arise is proved by the lower power utilized. The Brunton, which closely resembles the Waddell and the Rammell, cannot be expected to yield any better results. By the kind permission of Mr. Daglish, the results of a Rammell ventilator, recently erected at the Framwellgate Colliery, are here given: diameter of ventilator 22 ft., with 20 in. steam cylinder and 102 revolutions per minute; volume of air 53,600 cubic feet per minute, with a water guage of 2¼ in.; result, 40 per cent utilized. One of the chief reasons of the low useful effect of these exhausting fans is that they are exposed throughout the entire circumference to the external air, which rushes in behind the vanes to supply the vacuum formed by their revolutions; but this vacuum ought to be supplied only from the mine to be ventilated, and it was this consideration, and the practical proof that this injurious effect was inherent in open running fans, that led to the casing of the Guibal ventilators, and discharing the air at only one part of the circumference. This step, however, was attended with the objection that the air was discharged with a high velocity, viz: the velocity of the periphery of the fan, and carried away with it a most important store of force, the partial utilization of which has been effected by adapting the principle of *evased* tubes to the expanding chimney, in which the casing of this ventilator terminates. The air entering its base at a high velocity, leaves the chimney at a reduced velocity proportionate to the increased area of the outlet, and in this action restores a considerable amount of power it would otherwise carry off. An adjustable shutter was next found necessary, in order to regulate the size of the outlet and the various conditions of the volume of air required and resistances. A series of very interesting experiments had been made, showing the steadily improved results obtained from the ventilator, as the casing chimney and shut-

ter, in its accurate adjustment, were consecutively added. Generally, as to the powers supplied from the steam boilers for working these ventilators, 60 per cent was found to be utilized; but it must be noted that this amounted to at least 80 per cent of the power actually transmitted to the ventilator, as one-fourth of the boiler power must be allowed for the loss due to the friction and imperfection of the steam engine. One of the ventilators (of which several examples were now in use in this country of 36 ft. diameter) had been recently started in Belgium of 40 ft. diameter, but detailed experiments had not yet been made upon it. It was arranged to work at the speed of 80 revolutions per minute, producing a ventilation of 150,000 to 200,000 cubic feet of air per minute, under a depression of the water gauge of about 7 in., which was certainly the maximum requirements of any known condition of mines. Indeed there could be no question that any practical requirement in the ventilation of mines could be satisfied by this system, and it could not be surpassed in simplicity of construction, small liability to accident, and the little wear and tear to which its working parts were subject. The paper next pointed out the peculiarities in the Guibal ventilator—as to the concentric form of the casing and as to the curving of the vanes—and it then dealt with the second class of mechanical ventilators—that in which the principle of variable capacities, as in the pump, was involved. Struve's air-pump ventilator was the best known of the class, and consisted of two gasometer-formed pistons working in rings of water, alternate upward and downward strokes drawing air from the mine, and forcing it into the atmosphere by means of suitably arranged valves. The Struve was, when well constructed and in good order, capable of producing a very satisfactory exhaustion, but for certain reasons it did not offer the advantages for mine ventilation which the centrifugal action fan did. The useful effect was from 40 to 45 per cent of the boiler power, when all the working parts, and especially the air valves, were in good condition. In conclusion (to quote the words of the paper) the economy of fuel, if neglected hitherto, has now become of paramount importance. To increase the amount of air in any given time, the mine requires the consumption of an increased quantity of fuel, proportionate to the cubes of the volumes; thus, for twice the volume eight times the fuel. Hence the best system of ventilation is that which, under the same conditions of mine and the same amount of first outlay, produces the maximum work for one pound of coal consumed, so long as such ventilation compares satisfactorily with any other in the points of durability and cost of working, and possesses the quality of adaptability to all the varying conditions which are met with in mining operations.

TESTS OF STEEL RAILS.—Messrs. John A. Griswold & Co.'s circular thus describes their method of testing steel rails:

"1st. A test ingot from each five-ton ladleful of liquid steel is hammered into a bar, and tested for malleability and hardness, and especially for *toughness*, by bending it double cold. In case any test bar falls below the standard established as suitable for rails, all the ingots cast from that ladleful of steel are laid aside for other uses.

"2d. All the ingots, and each rail rolled from them, are stamped with the number of the charge or ladleful. A piece is cut from one rail in each charge, and tested by placing it on iron supports a foot apart, and dropping a weight of five tons upon the middle of it, from a height proportioned to the pattern of rail. A blow equivalent to a ton weight falling 10 to 15 ft. is considered a severe test. We use a five-ton weight falling from a less height, believing that it more nearly represents in kind (although it of course exaggerates in severity) the test of actual service in the track.

"In case a test rail does not stand the blow deemed proper and agreed upon, the whole of the rails made from that charge or ladleful of steel are marked No. 2, and sold for use in sidings, where their possible breaking would do no great harm, and where their greater hardness and resistance to wear would be specially valuable.

"In addition to this double test, the rails are rigidly inspected for surface imperfections.

"We believe that these tests render it practically impossible for us to send out rails of inferior quality.

"We farther invite railway companies to send inspectors to our works to witness the tests mentioned, and other tests and inspections agreed upon."

THE ELLERSHAUSEN PROCESS.—We give elsewhere some interesting details. In a future number we shall describe a modification which will prove of still greater interest.

BOILER EXPLOSIONS.

From a paper on "Government action with regard to Boiler Explosions. A statement of various plans for the object of discussion." Read before the British Association by Mr. LAVINGTON E. FLETCHER, C. E.

It is not in accordance with the rules of the British Association for Reports presented by Committees appointed to investigate and report on certain subjects, to be discussed in the meetings of the Sections. There are circumstances, however, at the present time, that render it especially important that the opinion of the members of the British Association should be fully expressed on many of the questions touched on in the report just read relative to Coroners' Inquests and Steam Boiler Explosions. The Home Secretary stated in his place in the House of Commons very recently that he would do his utmost, in the recess, to prepare a measure for the suppression of steam boiler explosions, so that it is of great importance that suggestions from all parties should be invited on this subject, and that the various plans proposed should be fully considered, so that the whole question may be well sifted. Under these circumstances I have, under the advice of one of the Secretaries of the British Association, prepared a brief secondary paper, on which it will be in order to raise a discussion. After the Report already presented to the Association, relative to Coroners' Inquests and Boiler Explosions by the Committee appointed to undertake that duty, I need do nothing more in this paper than name the points on which it is desired to obtain the views of the members of the Mechanical Section of the British Association.

The constant recurrence of boiler explosions, and the number of lives annually sacrificed therefrom, has aroused public attention to this subject. The public begin to suspect that these disasters are not so accidental as it has for a number of years been attempted to make out, but that they might, after all, be prevented. The system of periodical boiler inspection has proved itself sufficient to accomplish this task, and therefore the public naturally ask—why do not all steam users have their boilers inspected, and if they neglect this simple precaution, which has now been adopted by so many for the last fourteen years, why should not the law step in and compel them to adopt it?

This, therefore, opens the first question, whether it is expedient or not for the Government to interfere in the matter of the prevention of steam boiler explosions, and if so, in the second place, what would be the best mode in which the Government action should be taken. In answer to this second inquiry there are at least three plans now before the public, of which a brief outline may be given.

One of these plans is that the Government should take the supervision of every boiler in the country, with the exception of locomotive and marine, and through the medium of the Board of Trade should test all new boilers, and periodically examine them when set to work, as well as all others already in use, the examinations being made both when the boilers are at rest, as well as when at work with steam up.

All Englishmen have a strong dread of Government interference, and of the introduction into this country of the continental paternal system, fearing lest it should hamper progress and fetter individual action. This measure therefore is one which, to say the least of it, is calculated to provoke considerable opposition.

Another plan is, to render inspection compulsory, but not that the Government should take the task of examining boilers into its own hands, that is to say, it is proposed that no steam user should be allowed to work a boiler that had not been examined and certified as safe by some local inspection association or insurance company, duly authorized by the Government as competent to the task.

This plan has certainly less of the air of the continental paternal system about it, and appears more adapted to the usages of this country, though it by no means appears to be free from difficulty in its application. It is important that the integrity of the inspections should be preserved, and it may be well to suggest for consideration, whether there might not be a difficulty in securing this if the question of deciding on the safety of all the boilers in the country was handed over to a number of competing joint stock companies. Joint stock companies clearly exist for the sake of dividends, and it is difficult to see, if they are to be paid by steam users for granting certificates for the safety of their boilers, how the integrity of those certificates could be secured under a pressure of competition for business. Judges, to be impartial, should not be remunerated by those whose cases they have to adjudicate, more especially if their payment depends on giving satisfaction. It is feared

that under such a system, inspections might grow lax, and that the sale of certificates would soon be not unlike the sale of indulgences in days gone by. It is therefore a point for discussion how far it would be wise to commit the safety of all the boilers in the country to the charge of commercial competing companies intrusted with the monopoly of the sale of boiler certificates. Possibly there may be some way of meeting this difficulty, but it was thought well to throw it out for discussion on the present occasion.

A third plan is that every steam user should be left perfectly free to lay down what description of boiler he may think best, and to enrol it or not, either with a Boiler Inspection Association or Boiler Insurance Company as he sees fit, and, indeed, that he should be free to do just what he likes as long as he does not burst his boiler, but in the event of explosion it is proposed that the Government should then step in, make a most searching investigation of the facts, and publish the information for the benefit of the community at large. On this system the steam user would be left perfectly free in his choice of means, but would be held responsible for results, and, in the event of explosion, would be open to a claim for damages from relatives of those killed by the failure of his boiler. This plan, it is argued, would act preventively, inasmuch as it would, it is hoped, arouse to suitable vigilance all those connected with the use of steam, which is all that is required for the prevention of steam boiler explosions.

These are three of the principal plans now before the public. The first proposes to act on the paternal system, and to take every boiler under the Government wing. The second does not propose that the Government should undertake any inspections itself, but that it should leave them to duly authorized local associations, rendering it, however, compulsory that the steam user should avail himself of one or the other of these organizations. The third plan goes on the principle of believing every man innocent till he is proved guilty, and of punishing offenders in the hope that by so doing a repetition of the offense by others will be prevented.

Such is a brief recapitulation, and but little more, of the measures now before the public, while the few suggestions that have been added to this brief recapitulation have been thrown out more to stimulate discussion than by way of advocacy in the case of either plan, and full discussion is now invited on these questions from the members of the Mechanical Section of the British Association.

ON CANTING RAILS.

By W. Airy.

From "The Engineer."

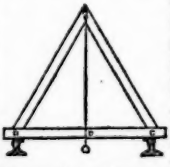
It will generally be found on railways that the amount or cant on curves which the outer rail receives is considerably less than the theoretic cant due to the highest ordinary speed maintained on the line. Nevertheless it is maintained in works on civil engineering that the full maximum cant which the formula demands ought to be insisted upon. Now, when experience has led to a universal system of departure from theory, it may safely be affirmed to be practically correct, and the writer had abundant opportunity of investigating the question. There are two important reasons why the cant should be kept under rather than over the cant due to the highest ordinary speed on the line. First, because a train goes more steadily round a curve when bearing constantly and firmly against the outer rail; and secondly, because when bearing hard against the outer rail, the coning of the wheels assists the motion round the curve. Now, with regard to the first of these reasons, it is well known that nothing tends so much to make engines run off the line as allowing play between the rails. So long as the wheels run steadily and closely between the rails, the train is safe, and it would require a vast force to make it leave the metals; but when the engine has leave to play between the rails, it begins to roll and oscillate from side to side, and has a tendency to mount the rails and leave the line. So well is this known that at crossings, where great steadiness is required to avoid injury to the points of the crossing, it is customary to reduce the gauge to the extent, in some cases, of $\frac{3}{4}$ in. Now, on a curve, if the cant be not too great to permit it, the centrifugal tendency will ensure the steady bearing of the wheels against the outer rail, and the train will run steadily round; but if the cant be rather too large for the speed, the engine will acquire a violent oscillatory motion—it will fall off from the outer rail and come upon the inner; then in consequence of the inequality of the lengths of the outer and inner rails, aggravated in this case by the coning of the wheels, it will be

thrown back upon the outer rail, and so on. The above would, of itself, form a very sufficient reason for keeping the cant less than that due to the highest ordinary speed on the line; but if the wheels are coned as they usually are, it would seem quite suicidal to cant the rails so much as to throw the pressure upon the inner rail; for then the larger circumference of the wheel would be running upon the inner rail, and consequently upon the shorter curve; the engine would in consequence receive a violent twist and be thrown against the outer rail with its front not tangential to the curve, but sensibly inclined to it, and the tendency to mount the rails would be very great. For both the foregoing reasons it would appear advisable in all cases to keep the cant rather below than above that due to the highest ordinary speed on the line, and the practice of engineers in so adjusting the cant is fully justified.

There is a special difficulty in correctly applying the cant at the commencement of the circular curve. The reason is that the curve commences abruptly, and so, in consequence, ought the cant to commence abruptly. When an engine passes off a piece of straight upon a circular curve, it is suddenly exposed to the full centripetal force due to that curve; the effect of this is to give the engine a sudden jerk, similar to a blow, and tending to twist the engine round in the direction of the curve. The effect of this twist, however, remains unbalanced, and prevents a repetition of such shocks as the engine passes along the curve; and if the rails be not overcanted the motion is as smooth as on a piece of straight. But it is impossible to apply the cant suddenly, as the curve is applied; and to apply the cant gradually on the piece of straight leading up to the curve would have the dangerous effect of making the engine roll and oscillate as already described. So that there seems to be no proper remedy for this inconvenience, except by flattening the curve at the commencement, either by eye, in the manner of platelayers, or by the use of easier and more gradual curves than the circular curves which are usually adopted.

There is an important question suggested by the numerous girder bridges on the Charing Cross Railway. Some of these, at Southwark-street and London Bridge, are on sharp curves, and the question arises, Ought not the girders that carry these bridges to be canted? Evidently they ought. The girders are subjected to two forces: one a vertical force due to the weight of a train, the other a horizontal force due to the centrifugal force of the train on the curve. The combination of these two forces give rise to a resultant force inclined to the vertical, and the girders, in order to meet this force fairly, should be also inclined to the vertical. This inclination is by no means insignificant in amount; it corresponds, indeed, to the inclination of a straight edge laid across the rails to the horizontal, when the rails are properly canted; and this on a girder 12ft. high would appear very considerable. Without, however, insisting upon the full inclination due to the centrifugal force, it is quite certain that a considerable degree of cant might be advantageously applied to the girders on curves; and it is, at all events, to be borne in mind that if a girder be not canted at all, or only moderately canted, an engine passing along the curve at a high rate of speed puts a far greater strain upon the girder than if it passed at a slower rate; and this strain attacks the girder in its weakest point, viz: its tendency to buckle. Such girders should, therefore, be amply stiffened by lateral plates and angle irons.

It is often necessary to check the amount of cant which the platelayers have given on different curves along a considerable length of railway, and for such purposes it is useful to have an instrument adapted to the rapid measurement of the cant. The writer adopted the following method:—A B C is a symmetrical triangular framing of strong wooden laths; B C is the gauge 4ft. 8½ in.; and A D, the perpendicular from A upon B C, is also 4ft. 8½in. From the point A is suspended a plumb-bob, and the rod B C is graduated both ways with inches and parts starting from the point D as zero. Thus, if there be no cant on the rails, and, consequently, their tops are at the same level, the plumb-line cuts B C at the zero point D; and if the rails are canted, then, since A D is equal to B C, the deflection of the plumb-line in inches from D will be equal to the cant on the rails, and the cant can be read off rapidly from the rule itself.



THE REPORT of the State Engineer of New York on Railways, is just out.

THE RESISTANCE OF ARMOR PLATES.

A paper on the Penetration of Armor Plates with Long Shells having Large Bursting Charges, fired obliquely, read before the British Association, by JOSEPH WHITWORTH.

At the meeting of the British Association at Norwich last year, I contributed a paper to the Mechanical Section "On the Proper Form of Projectiles for Penetration through Water." This paper was illustrated by diagrams showing the effects proper on an iron plate, immersed in a tank of water by projectiles with flat-hemispherical and pointed heads.

In that paper I claimed for the flat-fronted form of projectiles made of my metal three points of superiority over the Palliser projectiles adopted in the service.

1. Its power of penetrating armor plates even when striking at extreme angles.

2. Its large internal capacity as a shell.

3. Its capability of passing undeflected through water and penetrating armor below the water line.

This latter feature was, I think, satisfactorily proved by the experiments described last year, and I now desire to draw the attention of the section to the experiments I have made for illustrating the penetrative power of long projectiles with the flat front, fired at extreme angles against iron plates.

These experiments are illustrated by the projectiles actually fired, and the plates they penetrated, which are laid on the table.

The gun from which all the projectiles were fired is called 3-pounder, though capable of firing much heavier projectiles; it weighs 315 lbs. and the maximum diameter of its bore is 1.85 in.

The charge of powder used in all cases was 10 oz., and the weight of the 6 diameter projectiles is 6 lbs.

No. 1 is a portion of a plate 2 in. thick, penetrated by the 6 diameter flat-fronted projectile, at an angle of 35°.

No. 2 is a similar piece of plate 1.7 in. thick, completely traversed at an angle of 45° by the flat-fronted projectile No. 2, which buried itself to a depth of 30 in. in a backing of iron borings.

No. 3 is a piece of plate 1.75 in. thick, penetrated at an angle of 65° by the flat-fronted projectile No. 3.

No. 4 is a plate 1.7 in. thick, nearly penetrated at an angle of 45° by the 3½ diameter flat-fronted projectile No. 4.

No. 5 is a plate 1¼ in. thick, against which the *pointed* projectile No. 5 was fired at an angle of 45°. The projectile failed to penetrate the plate, being deflected by the pointed form of bend; the distortion of its shape shows the force with which it struck the plate, and proves the excellent quality of the material which could resist such a test.

No. 6 is a plate also 1½ in. thick, against which a Palliser projectile 2¼ diameter long made of Pontypool white iron, with the *pointed* form of head, has been fired; the projectile has scooped out a furrow 4 in. long and $\frac{7}{10}$ in. deep. It broke up into fragments.

The plates Nos. 1 and 3 were purposely thicker than the projectiles could quite pass through, in order that the "work" of the projectiles might be as severe as possible; an examination of the projectiles themselves will show how well they have withstood the severe strain to which they have been subjected.

The data thus obtained fully establish, I think, the superiority I claimed for the flat-fronted projectiles made of my metal, and satisfactorily prove:

1. That the flat-fronted form is capable of piercing armor plates at extreme angles.

2. That the quality of the material of the shell enables their length to be increased without any risk of their breaking up on impact, and thus increases their capacity as shells.

3. That this increase in length, while adding to the efficiency of the projectile as a shell, in no way diminishes but increases its penetrative power.

4. That the amount of rotation I have adopted in my system is sufficient to insure the long projectile striking "end on," and thus to accumulate the whole effect of the mass on the reduced area of the flat front.

These experiments show, further, that the Palliser projectiles fail to penetrate when striking at an angle, solely on account of the form of the head; the Whitworth projectile, which resisted the shock and did not break up, being deflected in precisely the same manner as the Palliser projectile which was shivered into fragments.

The objections I made in my paper last year to the Palliser projectile—1st, that its form of head causes it to glance off, and, 2d, that the brittleness of its material causes it to break up on impact—I have now proved to this section.

The facts illustrated by these experiments are not of recent discovery. Ever since 1858, I have experimented upon and advo-

cated the flat front. I have on the table a small plate, ½ in. thick, experimented upon in 1862, with hardened steel bullets fired from my small-bore rifle. No. 39 is the hole made by a flat-fronted bullet, which has penetrated the plate at an angle of 45°. No. 40 is the indent of a hemispherical headed, and No. 40 of an ordinary round-nosed bullet, both fired at the same angle of 45°. These three rounds were fired in 1862.

Within the last few days I have had a Palliser shaped bullet fired on the same plate at the same angle, in order to compare the effect produced on a larger scale on plate No. 6. It is interesting to observe how closely the effects obtained with the small calibre of the rifle agree with those of the 3-pounder gun, which form the subject of this paper.

These experiments were made with a gun of small calibre from considerations of economy and convenience, but I have always found that what I could do with the smaller calibres of my system could be reproduced in the larger sizes, and from my past experience I feel warranted in asserting that the effects of penetration now exhibited could be repeated on a proportional scale with my 9 in. guns at Shoeburyness, or with 11 in. guns my firm are now engaged in constructing.

A glance at the formidable nature of the projectiles thrown by these guns, and a consideration of the effects they may be expected to produce, will show the importance attaching to the question of penetration of plates by long projectiles.

The 9 in. guns, to which I have referred, weigh 15 tons each, and are capable of firing powder charges of 50 lbs.

A 9 in. Armstrong shell, five diameters long, weighs 535 lbs., and will contain a bursting charge of 25 lbs.

I have no hesitation in saying that these projectiles would pierce the plated side of a ship, at a distance of 2,000 yards, and at some depth below the water line.

The 11 in. guns will weigh 27 tons each, and will be capable of firing 90 lbs. powder charges.

The 11 in. shell, five diameters long, will weigh 965 lbs., and will contain bursting charges of 45 lbs., and would pierce the side of the ship Hercules, plated with 9 in. armor, at a distance of 2,000 yards.

Were it not that the increased destructiveness of war must tend to shorten its duration and diminish its frequency, thus saving human life, the invention of such projectiles could hardly be justified; but believing in the pacific influences of the most powerful means of defense, I have named these long projectiles the "*Anti-war*" shell.

The principle I have always insisted upon, and laid down for my own guidance in artillery experiments, when either a low trajectory or penetration is required, is "*that every gun should be capable of withstanding the largest charge of powder that can be profitably consumed in its bore.*"

I have drawn up a table of the sizes of the bores of my guns, with their proportionate powder charges, and can undertake that they shall be fully equal to this duty, and realize the highest possible consumption for a given quantity of powder.

But the guns adopted in our naval service are not equal to such a test, nor, as I believe, are they so proportioned as to realize the best effect from the quantity of powder they consume.

Four guns of 12 in. bore have lately been put on board the Monarch; they weigh 25 tons each, and fire charges of from 57 lbs. to 67 lbs., and projectiles of 600 lbs. weight. I have no doubt that these guns have been made with all possible care, and are as strong as their material and construction admit of their being; but if the weight of these guns was in proportion to the capacity of their bore, and the material were the best that our metallurgical skill could supply for such a purpose, they ought to fire 117 lbs. of powder, and projectiles of 1,250 lbs. weight. These would then be indeed efficient weapons, but at present they are more formidable in name than in reality. We are often flattered by being told that we have the best guns in the world. That may or may not be the case; but I think we should not rest contented while we are still so far from having attained all that our present advancement in mechanical and metallurgical science has rendered possible to us.

IRON RAILS.—We hope to be able to present to our readers in the next number, a *proof*, drawn from the experience of one of our leading railways, that good iron rails can be produced by paying a reasonable price. There purports to be a doubt on this subject in the minds of our railway managers, but we believe that they have not had an opportunity to familiarize themselves with the facts—and these we hope to present in convincing shape.

IRON AND STEEL NOTES.

THE POMEROY PATENTS.—The Pomeroy Patents Company possess the following patents for the improved manufacture of Iron and Steel:

1st. For the smelting and refining of Iron in the blast, cupola, puddling, or other furnaces, by the combination of hydrogen in the shape of steam or water, with Franklinite or zinciferous ores.

2d. For the manufacture of cast-steel from the refined iron.

3d. For a hot air double reverberatory furnace for the manufacture of steel or balling up steel sponge.

4th. For a desulphurizing, deoxidizing and carbonizing furnace for making steel sponge.

5th. For an improved method for manufacturing imitation Russia Sheet Iron.

6th. For covering iron with copper or other metals, such as bolts, spikes, nails and sheets.

7th. For movable grate bars for the steel and sponging furnaces, so as to keep the grates clean without opening the doors.

The great advantage of the hydrogen process for the purifying of iron has been abundantly proved. But the chief object since the foundation of the Company has been to demonstrate their steel patent for making steel suitable for rails. For this purpose they erected a furnace at Newark, N. J., which proved of remarkable power, melting old iron rails, refining, carburizing into steel, and casting the ingots in from 2¼ to 2½ hours from the time of charging the old rails. Some very fine ingots of steel were produced, which were proved and tested in Philadelphia, to be of superior quality. The work was done in the presence of many experts and other parties, who all expressed themselves satisfied with the results. The irregularity of the old rails and the difficulty of getting a material for the bottom of the furnace to stand so great a heat, were the principal difficulties encountered; but the managers are fully persuaded that these objections will be overcome and the process become a success when a new and improved furnace is erected and a material proper for lining obtained. While making these trials, parties applied to have steel sponge worked in the furnace to try to convert it into steel direct. After many trials it was found to be impossible on account of the great quantity of slag made from the sponge; but it was found that the furnace had superior powers for extracting the iron and that it could then be rapidly balled up into malleable iron, requiring only hammering to make superior blooms for converting into steel, rolling into rails, or other purposes.

The result being so satisfactory, the next requisite was to get a sponging furnace that would do the work thoroughly, expeditiously and cheaply. In this the managers think they are successful, having reduced the time of sponging the crushed ore to about 3 hours, or working continuously 3 heats in 24 hours. This process formerly required ten to twelve days, and the time has been gradually shortening. With improved furnaces, they will be able to reduce the time to six hours, or 6 heats in 26 hours. By these improvements the manufacture of rails can be reduced from $10 to $15 per ton, according to facilities for obtaining coal and ore. The quality will also be very superior to the iron now used for rails, and by proper care in balling up, a small percentage of carbon may be left in the bloom to form the head of the rail, thus making it but little inferior to a steel headed rail. Another great advantage, and a very important one is that the expensive blast furnace will be dispensed with, and works to turn out an equal quantity of blooms, can be erected for about half the cost of furnaces to turn out an equal quantity of pig iron. The furnaces are all so simple in construction and working that there is no great risk of any serious accidents, and only a moderate degree of wear and tear; thus avoiding the great peril of blast furnaces; also the time for erecting works to make blooms, would not be but half the time required to erect blast furnaces. At the experimental works at Newark, magnetic 60 per cent ore has been worked. The balls made were hammered and rolled at Trenton, into a rail 28 feet long, 68 lbs. to the yard, weighing 626 lbs. This rail has been pronounced by all who have seen it, as of superior quality and finish. A piece of the head from the waste end of the rail, has been tested by Whitney & Sons, Philadelphia, for tensile strength, as follows:

No. 1,	piece tested	66,712 lbs.,	per square inch.
2,	"	66,850 "	" "
Average,		66,780 "	" "

This is 25 per cent stronger than common rails, and ten per cent stronger than the standard for bridge iron.

The ore was good, but had 1⅛ per cent of sulphur and ¼ per cent of phosphorus in it, and yielded 50 per cent in the balls. The great strength is mainly due to the fluxes used in the sponging and balling, together with the use of hydrogen and Franklinite, which eliminate the impurities and make a neutral iron; being so pronounced by an experienced smith.

The refuse of hematite or "slack," has also been sponged and balled, yielding 34 per cent. An ore containing 6 per cent of titanium, has been balled and will no doubt hammer well.

These trials indicate that all kinds of ore can be well worked by the Pomeroy processes. Also that ores too sulphurous or refractory to be worked in the blast furnace can now be utilized. The process also saves at least one ton of coal in making a ton of blooms from the ore, compared to the blast and puddling process for blooms. Pea coal, or fine bituminous, answers for sponging.

THE UTILIZATION OF WASTE GASES FROM BLAST FURNACES.—The blast furnace proprietors who have adopted one or other of the different methods employed for bringing down the gases report satisfactorily of the result. This with regard to one plant of furnaces is seen in the circumstance that between 250 tons and 300 tons of fresh drawn slack heretofore required in raising the steam for their blowing engines and for heating the blast is now being offered for sale. The concern is that of the Parkfield Iron Company at Wolverhampton. If the practice should be extended throughout the whole of the district, and the proportionate saving equal to that here stated, a large amount of economy will have resulted; for notwithstanding that in some cases the adaptation oven of the least expensive method is regarded as costly, still the ultimate saving is very marked. Speaking of this one case in particular, the saving may be put as equal to the developing of 500-horse power out of nothing!

IRON AND STEEL—A NEW BLAST HEATING APPARATUS.—Homer Hamilton, Esq., of Cleveland, has invented a new blast heating apparatus which, if it performs all that is claimed for it, will prove valuable to furnace owners. The apparatus consists, first, of eight or ten large pipes, divided by means of a horizontal or inclined partition into two chambers, of which the upper one opens at one end and the lower at another. Upon each of these base pipes are eight upright pipes, opening into the upper chamber of the base pipe, and closed at the top. Inside of each of the upright pipes is a smaller tube, opening at one end into the lower chamber of the base pipe, and at the other into a chamber at the upper part of the outer upright pipes. The object of the invention is to construct a simple and effective device for heating the air that is carried into a blast furnace, and consists in the above arrangements of pipes, so that the air will be exposed in thin sheets to heated surfaces, and expansion and contraction will not injure the apparatus. Its operation will be as follows: The burning gases will surround the upright and base pipes, and will heat their surfaces. The air is forced into the lower compartment of the base pipes, thence it passes up into the inner tubes to the upper part of the upright pipes, which are rounded, enlarged and depressed in the center for the purpose of facilitating the transmission of air from the inner tubes to the outside upright pipes, and to avoid friction. The air then passes down the upright pipe outside the inner tube, exposed in a thin sheet to the heated pipe, and is thence transmitted to the upper compartment of the base pipe. It then goes into the blast furnace, or to another heating apparatus of similar construction. It must be understood that for a blast furnace of usual size a series of eight or ten base pipes with their upright and inner tubes, should be provided in order to have a sufficient heating surface. The pipes all support themselves, and cannot strain any supporting frame or other machinery. For that reason a much greater degree of heat can be obtained—a very desirable thing in blast furnace economy. The points of the invention are: First. The arrangement of base pipes and uprights so that the air to be heated will pass from one compartment of the base pipe through all the verticals into the other compartment. Second. The rounded enlargement on the upper end of each upright pipe to prevent friction of the air. Third. The construction of the apparatus so that the air is exposed to the heated surface of the outer upright pipe in thin sheets, and is therefore uniformly heated.—*Pittsburgh Commercial, Aug.* 7.

SPECIAL METHOD OF BLOOMING.—We have lately examined a modification of the Catalan process in the old form of the forge-hearth, at the Logan Ironworks, Bellefonte, which is extremely simple and direct, resulting in the forming of, commercially speaking, an almost absolutely pure iron. The furnace is a few inches above the general floor of the forge-house, and the size about large enough to make one bloom of 200 or 225 lbs. It is about three by four feet, the long way running back from the workman. The instrument for turning, lifting, and aggregating the iron is called a "furgeon," and answers to the rabble of the ordinary puddling furnace. The waste heat passes up and through a chamber immediately over the forge-hearth, where the pigs are placed which become red hot before they are ready to be drawn down upon the bed of charcoal previously prepared. The pigs thus drawn down upon the charcoal bed are covered and the blast turned on into both tuyeres right and left. After a few minutes the iron begins to melt; it is decarbonized by the blast, is worked into shape by the furgeon, and then lifted up clear of the bed and laid upon the top of the same bed again, some additional charcoal put around, and the blast turned on. The iron now is melted in what is called the sinking process, wherein the iron drops through the coal into the hearth until entirely passed into the hearth; there it is again agglomerated into the ball, or "loup." by the furgeon (pronounced *furgun*), the blast having previously been turned on fully; it is then lifted out a balled loup and carried to the hammer. The cinder is tapped off through a hole in the front iron plate, and is rich in iron, with so much silex that it easily emits sparks when the penknife blade is struck against it. Of course, this process is attended by a large loss of iron, while the loup, which gives rise to the cinder, is not thereby improved, as in the puddling furnace. But in this particular instance the iron is singularly pure, and the blooms command $85 per ton at the forge. One ton and a half of pig yields 2,464 pounds of bloom. The charcoal furnace yielding the iron is nearly adjoining the bloomary.

This furnace is only 32 feet high, about 26 inches across the tunnel-head opening, 8¼ feet bosh, and the slag is allowed to flow out from the hearth whenever it rises above the fore hearth. The breast is covered with a simple plate of iron; the cinder is always in sight; as soon as the iron appears, the crucible, or tapping-hole, is opened and the iron is tapped off into iron moulds. There are three casts per twenty-four hours, two tons per cast; 150 bushels hard coal (18 pounds to the bushel) to the ton made. Charges, 700 to 750 pipes ore (brown hematite), 27 bushels charcoal, 80 pounds gray limestone of good quality; pressure, a half to three-quarters of a pound per inch; nozzle, two and a half; two wooden blowing cylinders worked by water-wheel. Some finery cinders, about thirty to forty pounds, are added to the charges and said to improve the iron, which at present, May 26th, 1869, is all forge iron, and used at Stewart & Co.'s wire factory, and reported as a very fine iron.

This bloomary process is interesting as an example of blooming from pig iron, and is the same process spoken of in a certain United States report, if we mistake not, as not existing in this country.—*American Exchange and Review.*

INCREASING EXPORTATIONS OF IRON AND STEEL FROM ENGLAND.—It has been shown says the "Engineer" that, notwithstanding all the outcry which has been raised of late years as to foreign competition, the exports of iron and steel from the United Kingdom attained a larger total in 1868 than in any former year. The quantity and value of the exports since 1859 is as follows:

	Tons.	Value.
1859	1,465,191	12,314,437
1860	1,442,045	12,154,997
1861	1,322,649	10,326,646
1862	1,501,451	11,365,150
1863	1,640,949	13,150,936
1864	1,502,964	13,310,848
1865	1,617,509	13,471,359
1866	1,683,390	14,842,417
1867	1,882,650	15,050,391
1868	1,945,246	15,021,907

MALLEABLE CAST IRON.—For the production of this material most of the German founders use first fusion pig, free from sulphur and phosphorus, or Scotch pig. Styria also furnishes a suitable iron which can be used only in the north of Germany, however, on account of the expense of transportation and high duties. On account of the competition of wrought iron, great cheapness is very essential to its sale. The makers keep secret the brand of iron which they employ, but it is well understood that the brands are not the same in different establishments. The iron is melted in plumbago crucibles, holding about 30 kilog. They are covered with porcelain lids, to keep out impurities and cinders which reduce the high heat requisite for the process. The fire in which the crucibles are placed is from 630 m. to 940 m. square, and is surrounded with bricks of porcelain earth. The use of blast is not advantageous, since the economy of time is offset by a greater consumption of coke. The natural draught of the chimney is sufficient when the furnace is properly constructed. An essential condition of success is a high heat at the moment of pouring. Practice enables the caster to estimate the heat of the furnace, and he recognizes the precise moment by plunging a bar of red hot iron into the crucible, from which, upon being withdrawn, the metal flies off in sparks. The crucibles are raised with tongs with curved jaws, and the pouring is done with all possible speed—the surface being first cleaned. By cementation the casting acquires the properties of wrought iron, having some analogy to steel. The operation consists in subjecting the castings to a prolonged red heat in a bath of pulverized red hematite. They are arranged in boxes of cast iron called muffles. These are square, and with air-tight covers. In arranging the castings in the boxes they are placed in layers alternately with layers of hematite. The cementing furnace is very simple. The grate is in front, and the draught of the chimney carries the hot air around the boxes. The heat should be conducted with care, starting rather vigorously, in order to reach the desired temperature quickly; then supplying the furnace at regular intervals. The cementation lasts three, four, and five days, according to the size of the pieces. A charge is about 350 to 450 kilogs of castings. In arranging the charges large pieces should not be mingled with small, and those muffles containing the larger pieces should be placed in the furnace first. On the other hand, the smaller objects are placed on the sole of the furnace. Without these precautions many pieces may be burned, or badly decarburized—the latter becoming something intermediate between iron and steel. When the operation is deemed complete the fire is allowed to fall, but the furnace is not uncharged until it has gradually cooled. Practice plays an important part in the management of the firing, as the temperature can be judged of only after prolonged experience.—*La Génie Industrielle.*

IMPROVEMENT IN ROLLING IRON.—A new description of roller, to be employed in the manufacture of iron plates, bars, tubes, &c., has just been invented by a roll turner, named Robert Robertson, who is at present employed in the Coatbridge Iron Works, the property of Messrs. Martin & Son. The invention, if it succeeds as well as it at present promises to do, bids fair to completely revolutionize the system of rolling, as the new machine possesses so many advantages over the one at present employed. The invention consists of having the rolls tubular, instead of solid as at present, with a stream of water introduced inside of the rolls. The advantages are said to be that the new rolls are from 7 to 8 cwts. per ton lighter than those in use at present, while the water inside the rolls prevents the heated iron from due expansion, while undergoing the process of rolling, and saves a great amount of drag upon the engine. The saving in this respect will be better understood when it is stated that in the item of brass bearing alone the amount of mean steam saved by the new invention is at least 15 per cent. No steam arises from the rolls while working, so that the workmen can pursue their avocations with greater ease and facility. No scales stick to the rolls, consequently the finished bar or plate presents a finer surface. The new roller will also last much longer than the solid rolls, while the chances of sudden breakage are reduced to a minimum.—*North of England Coal and Iron Trades Review.*

SIEMENS' OPEN HEARTH FURNACE.—Mr. Siemens informs us that the cost of the production of steel made in his open hearth furnaces, depends upon the cost of the materials, pig-iron, scrap and the cost of the labor. The following, however, is the cost of production in England, viz: for a charge of *four tons, three* such charges being made in 24 hours in each furnace.

10 cwt.	pig-iron.
3 tons 10 "	scrap steel.
8 "	spiegeleisen.
2 tons	coal.

Labor—five men (melter, assistant melter and three laborers.) Repairs, interest, management and royalty. This made the actual cost of the steel ingots £5 10s. per ton.

The cost of one of these furnaces here, with gas producers and all equipments, such as ladle, tramway, etc., would be about $14,000.

As to the durability of the furnace, the best evidence is contained in a letter from Mr. Siemens, dated February 16, 1869. He writes, "you will be interested to learn that the manager of the Bolton Steel and Iron Works (Mr. Webb), has told me that his furnace crown (open hearth steel melting) has stood 70 charges, and looks as good as new. At the lowest computation the furnace will last 100 charges, and the cost of repairs will amount to less than *one shilling* per ton of steel melted."

We quote again from a late letter of Mr. Siemens—"These furnaces are now in regular operation at Swansea, Bolton and Crewe, where first class steel is made by them; that made at Bolton having been tested by P. W. Barlow, Esq., F. R. S., on behalf of the Institute of Civil Engineers, who are desirous of establishing 'standards for the employment of steel in construction,' was found superior in tenacity and ductability even to crucible steel, and far superior to Bessemer steel."

We copied a paragraph which appeared in "Engineering" in reference to Mr. Samuelson of Middlesboro', England. We learn from an authentic source that it is quite true. Mr. Samuelson has ceased to manufacture steel according to the "Siemens-Martin" process, but his failure must not been held to affect the process, as he did not work according to Mr. Siemens instructions, but allowed himself to be guided by M. Martin, who was unacquainted with English irons, and he also followed his own notions. Moreover he had no chemist and consequently was working in the dark.

CLEVELAND IRON MAKING.—It seems but a short time since, and it is in reality less than three years, when the furnaces in the Cleveland district were making about one million tons of pigs yearly. Notwithstanding the depression in trade they are now reported to be turning out iron at the rate of 1,400,000 tons yearly, or nearly one-third of the whole pig-cast of England, Scotland, and Wales. The Cleveland ironstone is cheaply got, but it is lean and highly charged with phosphorus. Coke, on the other hand, is dear, and is likely to become dearer. But by the employment of the most complete mechanical appliances the cost of production has been brought to a very low figure. Had the Middlesboro' ironmasters access to the vast quantities of slack from the Durham and Tyneside pits, they would soon turn out a cheap coke by washing, but there would still be the long carriage by rail. The ironstone is calcined in kilns, but as it is not of the carbonaceous variety—that known as "blackband"—there is no opportunity of effecting the saving which, with that variety, is obtained by coking in close kilns, upon Mr. Aitken's plan, so successfully employed near Falkirk. Even 22 cwt. of the best coke to a ton of pigs seems a large quantity when the heat really absorbed in decomposition, liquefaction, and in raising the temperature of the air is considered. A good cupola in regular work will melt, of some kinds of iron, as much as sixteen times the weight of coke used. Yet cupolas vary greatly, and some, from various sources of loss, will not do half as well as this. And blast furnaces vary greatly also, some using, with the same materials, one-half more fuel than others. Yet it is difficult to see the way to any decided improvement in blast furnaces from which the gas passes off at a temperature hardly above 500 degrees, all the gas being saved and burned under the boilers and in the heating stoves so as to require no other fuel whatever.

The Cleveland forgemasters know how to make a good soft iron, hardly cold short, from their highly-phosphuretted pigs, which, in the ordinary course of things would work into cold short bars. The whole secret, if it be a secret, is in a liberal fettling with rich magnetic oxide of iron, of which large quantities are now purposely imported from Sweden. Mr. Gjers has made some very interesting analyses of the cinder, which was highly charged with phosphoric acid, while the puddled bar was of good, mild quality.

Puddling costs dearly in Cleveland. It is not long since it was 10s. 6d. per ton, but it is perhaps somewhat less now. It seems to be settled that none of the "mechanical puddlers" will ever answer, although Mr. Tooth managed to make some very fair blooms, eight years ago, in his revolving puddling churn. But why, after Mr. Bessemer's patent expires in February next, cannot it be adapted to some extent to puddling, so as to drive off not only the silicon, but a good portion of the carbon by air alone, leaving the puddler half an hour's work or less to be done by hand. A great deal was said, some year or two ago, about the so-called "Richardson process," which was merely injecting air under the surface of the iron in a puddling furnace by means of a tubular rabble. The injection of air in such a manner must have been very ineffective for two or three reasons, and although the treatment could not possibly do harm, it is difficult to see how it could, by being continued for but a few minutes, do any considerable good. Yet much was claimed for it at the time, although nothing is heard of it now. But why should not some modification of the Bessemer converter, on a small scale, and arranged to work into, say, half a dozen or more puddling furnaces, be arranged to bring the iron to the point where only the puddler could finish it? In this case, too, all the iron would be melted in a cupola, which would be cheaper than melting it in the puddling furnace. A large saving of labor and a considerable saving of coal might, it would seem, be thus affected. At any rate, the experiment should be carefully tried.

It would be interesting to know whether the so-called "Radcliffe process," of knocking five or six ordinary blooms into one before shingling, is still being practiced with success. It seems extraordinary that such a "process" should be the subject of a patent, although it may be more extraordinary that any forge master should adopt a "process" so likely to shut in cinder with the iron. The published tests of the iron made by this "process" showed an elongation, in breaking, of but about 5 per cent, which is very little, and indicates harshness and brittleness. By mistaking a column of figures in Mr. Kirkaldy's report, the "Engineer" reported the elongation as 30 per cent.

It would be interesting also to know whether Mr. Bramwell's suggestion, that all bar iron should be rolled in a hoop, can be successfully carried out. There are difficulties in the way of bringing together the two ends of a pile and welding them preparatory to hanging the ring upon an overhung roll, and the necessity for some means of shifting the roll into and out of the outer housing would create an additional difficulty. But, supposing all this once done, and that the hoop could be successively shifted from one grove to another, the bar or hoop would be rolled out with a continuous motion, without, "passing," and without any crop ends. It would be better afterwards to find the weld and cut the hoop there, when it would drop out a straight, clean cut bar.—*Engineering*.

MANUFACTURE OF NAIL-PLATES.—Hitherto much trouble has been experienced in finishing the wrought-iron plates from which cut-nails are made, the trouble arising from the adhesion of "scales" to the finishing rolls. This, by destroying the uniformity of the surfaces of the rolls, caused them to work unevenly and imperfectly, and consequently impaired the smoothness of the plates. A Pennsylvanian inventor has recently invented and put in operation a simple contrivance by which the rolls are automatically kept clean, thereby preventing all hindrance to their perfect operation and insuring the uniform smoothness of the plates. It consists in small friction-rollers so applied in relation with the rolls as to sweep the scales therefrom as fast as formed; the rolls being thus kept constantly bright. By this means, not only is avoided all the trouble of cleaning the rolls hitherto necessary, but the nail-plates are made much better. It is probable that the principle of the device will be applied with profit to the rolls of other machinery for shaping iron while hot.—*American Artizan*.

FORTY-TWO TON HAMMER.—In England a huge steam hammer, weighing 1,000 tons, is being made for the Russian Government. The hammer head weighs 42 tons, the anvil block 500 tons, and it is to be used in forging steel guns.

STEEL AT ANY PRICE.—The amiable journalists who, until the advent of "gunpowder steel," condemned all steel, are deriving consolation from the utterances of Sir William Armstrong, at the Newcastle meeting of the Mechanical Engineers. This gunpowder steel, invented by one Heaton, was, however, an exception to everything else. No words and no superficial measurement of type were sufficient to explore its virtues. It is explicable that Sir William has not visited the deserted "shanty" known as Langley Mill, and from the koran to be found there, developed his knowledge of steel. We are told that he was once one of the "steel at any price" party. So far from this, he has been a most uncompromising enemy of steel in all forms. He stood out, for a long time, and in spite of every recognizable fact, against steel inner tubes for his guns, without which they might almost as well have been constructed of leather. Indeed, there is no such thing now as an "Armstrong gun." The gun is Fraser's and Fraser's only, and he has not yet received the half of what he deserves for kicking aside the Armstrong delusion. Just as engineers complete their education they learn the value of steel, and it is merely a pity that the tergiversating journalists of whom we speak are not yet out of the woods in their wild goose search after evidences of its value.—*Engineering.*

THE PITTSBURGH STEEL WORKS.—The "Black Diamond" Steel Works of Park, Brothers & Co., are the largest in the city, covering five acres, and comprising a steel forge, rolling mill, converting building, melting houses, etc. Here are 17 steam hammers, 5 helve hammers, 7 steam engines, 4 trains of rod and bar rolls. The capacity of the works is 20 tons of cast steel and 10 of common steel, daily, the number of men employed, 240. This concern manufactures cast steel boiler plate for locomotive engines, tool steel, machinery steel, burglar proof safes steel, plough, and other agricultural steel. The buildings and machinery of the establishments are all first-class, and kept in the nicest possible order. This is a sample of the very best class of establishments in Pittsburgh.

The establishment of Messrs. Hussey, Wells & Co., one of the largest steel works in the city, has a capital of $1,000,000, runs 144 furnaces, and makes about 30 tons of steel per day. They employ about 200 men, and sell as fast as they can manufacture, which is the best point that can be made with regard to the steel-workers of Pittsburgh.—*Exchange.*

STEEL-HEADED RAILS.—Steel-headed rails are made at the Trenton (N. J.) Rolling Mills by the following process: The steel which is to form the head of the rail is first wedded to a quite thin piece of iron. The combined bar is then beaten and rolled down until the iron is very thin and the steel reduced to about half its former bulk. After this operation is completed, the whole quantity of iron requisite to complete the bulk of the rail is added to the bottom of the combined bar, and welded to the thin layer of iron. This process, it is asserted, doubles the strength of the weld between the iron and the steel, always a difficult operation to perform. The old process consists in welding the relative thickness of iron and steel at one operation, but the new method is reported to furnish better rails.—*U. S. Railroad and Mining Register.*

REDUCING ALUMINIUM FROM ITS ORES.—Mr. A. L. Fleury, of Boston, U. S., mixes pure alumina with gas tar, resin, petroleum, or some such substance, making it into a stiff paste, which is divided into pellets, which are dried in an oven, then placed in a strong retort or tube, which is lined with a coating of plumbago. They are then exposed to a cherry-red heat. The retort must be sufficiently strong to stand a pressure of from 25 to 30 lbs. on the square in., and be so arranged that, by means of a safety valve or tube, the necessary amount of some carburetted hydrogen gas can be introduced into the retort among the heated mixture, and the pressure of from 20 to 30 lbs. on the square in. be maintained. The gas alluded to is forced into the retort by means of a force pump. By this process the alumina is reduced and the aluminium remains as a spongy mass, mixed with carbon. This mixture is re-melted with metallic zinc, and when the aluminium has collected in a metallic state, the zinc is driven off by heat. The reduction is due to the carburetted hydrogen gas under pressure. The time required for reducing one hundred pounds of alumina earth, cryolite, or other compound of alumina, should not be more than four hours; when the gas can be applied in a previously heated as well as strongly compressed state, the reduction takes place in a still shorter period.—*Chemical News.*

RUSSIAN RAILS.—A great festival has lately been held at the Poutilof rail factory (St. Petersburg) on the occasion of the completion of 2,000,000 pounds (about 800,000 cwt.) of rails. The rise of this factory is mainly owing to the privileges granted by the Russian Government to companies purchasing their railway material in Russia, and to large orders for the governmental lines. Hitherto it might be reckoned that a considerable part of investments of English capitalists in Russian railway shares might come back in the shape of payment for rails and rolling stock. Now we see that, as regards rails, this hope must be given up; and the same thing would probably have taken place in respect of carriages, had not the new Struve's extensive carriage factory (near Moscow) been recently burnt down. Of locomotives and carriages we may further observe that Russian companies have always preferred the cheaper French and German supplies. The Poutilof rails are stated by Russian engineers to be heavier, and nearly twice as dear as the foreign, but more durable.—*The Engineer.*

BESSEMER'S LATEST PATENT.—Henry Bessemer, whose name has been long identified with improvements in the manufacture of iron, has recently taken out a patent in England on a new process, the object of which is to secure a more rapid and less expensive mode of fusing malleable iron and steel of different kinds, and to obtain cast-steel and homogeneous malleable iron therefrom. In order to accomplish this, the inventor avails himself of the property of gaseous fluids to rise in temperature in proportion as they are compressed, and he constructs furnaces of sufficient strength to withstand an internal pressure equal to two or more atmospheres, and retains in such furnaces the products of combustion under such an excess of pressure over that of the external air as will produce the high temperature necessary for rapidly fusing malleable iron and steel of any kind or quality.

RAILWAY NOTES.

TRIAL OF A NEW KIND OF RAILWAY IN FRANCE.—A commission was appointed to study and report upon a system of railway of which a specimen had been laid down by Mr. Geoffroy, of Rouanne, by the side of the road from Poilly to Charlieu, in the Loire. The principle of this railway, which is intended for local lines, is that the rails are laid on the natural profile of the ground, with the addition of a central rail, upon which work horizontal wheels wherever the curves or gradients are at all sharp—in fact a modification of Mr. Fell's arrangement. The report of the commission is not published, but the following are the conclusions of the reporting engineer: (1.) The system of railways presented by Mr. Geoffroy allows of trains being worked with perfect security on inclines of 0.06. (2.) The arrangement of the railway in those parts where the central rail is introduced seems to resolve the problem as simply and economically as possible. (3.) The breaking off of the central rail in those parts where the incline does not exceed 0.025 causes no inconvenience, adhesion of the vertical wheels being then sufficient; and the horizontal wheels take on and leave the central rail without any shock that can do injury to the machinery. (4.) The action of the brakes of the engine is sufficient to stop a train of twenty-two tons within 80 feet on the inclines of the experimental line. (5.) The engine and carriages pass without difficulty, and without the aid of the central rail, at the rate of twelve or thirteen miles round curves of 260 feet radius. (6.) The passage of the train by the side of the ordinary road did not appear to frighten horses very much; and in any case this inconvenience cannot be very great, on account of the ease with which the engine can be stopped. The effect will also be greatly diminished by the erection of a barrier that must be placed between the railway and the high road." We are sorry to say that the opinion contained in the last paragraph is entirely opposed to that of the engineers and others of Paris and Nantes with respect to the road locomotives and steam rollers, and the latter are not now allowed to be used in the day time, except the street be blocked, on account of the accidents that happened. Still, if costly works can be avoided by the use of a central rail, we may have local railways at a comparatively small expense elsewhere than by the side of high roads, and there is no reason whatever, except the objection of level crossings, why such simple railways should not be adopted. It is the opinion of the commission that there would be a saving of expense in the case of such a railway as compared with ordinary lines of 40 per cent, and that therefore it would be well to adopt the arrangement where the difficulties of the ground would render the construction of an ordinary railway too costly. —*The Engineer.*

THE PATENT SHAFT AND AXLE CO.'S WORKS AND PRODUCTS.—This company, says the correspondent of "The Engineer," employ at their two establishments—the Brunswick and the Old Park Works—from 4,000 to 5,000 hands, and that the department I visited occupies 400 workpeople, and turns out weekly over 300 pairs of wheels. My attention was first directed to the manufacture of some solid wrought-iron wheels with Kirtley's spokes fitted with best "double star" puddled steel tires, or tires of solid cast-steel, secured either with Mansell's retaining rings or ordinary bolt and rivet fastenings. Kirtley's spokes are rolled from B B iron in ordinary rolling mills. they are then bent into a triangular shape, so that when eight are placed together they form a complete circle, technically called a "skeleton." The machine in which they are shaped is called a spoke-bending machine. This apparatus has a bed similar to a planing machine, the "saddle" of which is worked to and fro by a cranked motion. The saddle has fixed upon it a center block, and two side blocks or arms. The center block, which forms the crown of the spoke, is moved horizontally by eccentric motion. The side blocks are then simultaneously brought together by a single movement of the machine, embracing the sides or legs of the spoke. After being thus shaped, another movement lifts up the spoke from the die, when it is ready for bossing; that is, the spokes, arranged in a circle or skeleton, are placed on a smith's fire, and the center part is heated to a welding heat, and a large washer formed by a steam hammer, also heated, is welded on to the center of the spokes by ordinary smiths' sledges. The spokes being sloped at the corners of the crown, leave when put together interstices in the shape of the letter V, which are filled up by what are called "V-pieces. The wheel is then ready to receive the tire. The accuracy of the former is, however, first secured either by ordinary lathe-turning, or perhaps (more frequently) by an ingenious apparatus expressively called a "squeezing machine." This machine consists of a circular bed-plate, on which is worked eight slides, which are worked simultaneously to one center, forming a perfect circle. The machine is capable of exercising a pressure of 1,500 tons after making due allowance for all friction. The tires, which are rolled, bent and welded, are also tested in what is called a "blocking machine," an operation which fully proves the soundness of the weld. The tire being expanded by heat is next shrunk on to the skeleton by immersion in cold water, and the wheel is then ready for the finishing touches, such as boring and grooving, to receive the key of the axle. The wheel and the axle are joined together by pressure under gauge by hydraulic power, being further secured by steel keys. The wheels in pairs are turned in wheel lathes to accurate dimensions, and to road gauge, after which they are dressed off and painted. The wheels vary in size from 18 in. diameter, for lorries, to 6 ft. diameter for engines.

AMERICAN LOCOMOTIVE REPAIRS.—From a number of reports of some of the leading American lines of railway, we have compiled, says "Engineering," the following statement of the average annual mileage of their engines, and the cost per mile for repairs. As a general rule, only train miles are reckoned by American railway managers, although in some of the following cases engine miles are reckoned in dividing for the cost of repairs per mile.

The cost of repairs, given in pence per mile, is in a depreciated currency, the cost in silver being about three-fourths that in paper. Allowance must, of course, also be made for the very high price of labor, and all materials, except wood, in the States.

The Reading, and the Baltimore and Ohio Railroads are very largely engaged in the coal traffic, the latter line having 239 goods engines out of a total of 290 of all kinds.

Name of Line.	Year.	Number of Engines.	Total Mileage.	Average Mileage for each Engine.	Cost of Repairs in *Pence* per Mile.
					d.
Pennsylvania	1868	431	8,693,328	20,031	6 04
Erie	1866	371	7,109,139	19,162	7.44
Baltimore and Ohio	"	290	5,564,036	19,186	6.75
Grand Trunk (Canada)	1868	298	3,270,743	21,951*	3.54
Reading	1868	269	4,500,135	16,730	6.44
Chicago & North-Western	1867	248	.....	25,000(?)	5 00
Illinois Central	1868	169	4,593,146	27,180	6.36
Boston and Albany	"	144	2,727,558	18,941	6.43
Chicago and Quincy	1867	122	2,648,551	21,709	6.54
Michigan Southern	1868	101	2,667,191	26,408	4 38
Michigan Central	"	98	2,055,049	20,969	6 27
Mobile and Ohio	"	94	1,167,204	12,417	14 34
Cleveland and Cincinnati	"	83	2,177,407	26,231	4.61
Cleveland and Pittsburgh	"	73	1,616,216	22,140	3.86
Louisville Nashville	"	66	923,471	14,000	4.72
Morris and Essex	"	57	922,847	16,295	4.23
Boston and Maine	"	43	892,661	20,783	4.50

*Equivalent average for whole year.

PERILS OF INDIAN RAILWAY TRAVELING.—A late number of the "Cornhill," gives the following interesting facts:—The only accidents peculiar to India are those which are the result of floods, cyclones, and such disturbances of the elements. In 1864, the lower part of Bengal was visited by a tremendous hurricane, but although sheds were leveled to the ground, roofs were torn away, and part of a train, including the engine, was blown over, no lives were lost. On this occasion damage to the extent of £50,000 was done to railway property. On another occasion, on the Bombay side, the results were even more disastrous. A viaduct on the Great Indian Peninsula Railway was carried away by the violence of a flood, and a night train following soon after ran into the vortex, taking with it a number of native passengers, fourteen of whom were killed. The bridge over the Nerbudda River, on the line between Bombay and Baroda, has more than once suffered injury from the violence of the torrent. In Scinde, on one occasion, a whole village on the banks of a nullah was carried away, and brought down a railway bridge in its ruin. Wild animals have also occasionally been the cause of accidents. The other day an elephant charged a train and was killed, but such was the resistance which he offered that the engine-driver was thrown off and injured. A buffalo has also been known to throw a train off the line by getting in its way. In spite, however, of these special causes, railway traveling is as safe in India as in England. Last year the number of fatal accidents was one and a half per million. There are perhaps more frequent cases of death from natural causes in Indian Railway trains than elsewhere, and the ominous heading "found dead" may be seen on the returns of casualties. The fact appears to be that many natives commence a journey *in extremis*, in the hope of reaching some sanctified spot where to die, and the vital spark expires before the poor creature can reach his destination.

FAST RUNNING.—The speed of the New York and Chicago Express, over the New York Central Railroad, has been as high as 51.7 miles per hour for 81 miles, between Syracuse and Rochester.

PEAT FOR LOCOMOTIVE FUEL.—The State Line Bavarian Railway has been worked with turf since 1847, or for above 20 years, rather from necessity than choice. The peat is got from the bogs of Haspelmoos. The method of its preparation is that of M. Exeter, whose statement is that he can produce 10,000 cubic meters of prepared turf per annum at a cost of 2.80 francs per meter. The turf, as dug or dredged, appears loaded with much admixed earthy matter; from this it is separated by grinding up, large dilution with water, and decantation of the water bearing the light peat particles still in suspension from the heavier earthy matter which has deposited. This is let to dry in layers exposed to the air like "hand turf," and then compressed in molds by power. From other sources of information on the subject of artificially prepared peat, we conclude that these results admit of being contested. As a locomotive fuel, turf, at the best, is a bad and troublesome one; it gives much smoke and sparks, leaves an evil smell after it, experienced in the train, and is so bulky as often to need supplementary wagons to feed the tender on a long run. There is also great waste by the broken particles passing through the firebars.

As to comparative heating powers (not theoretic, but taking into account all these circumstances), the result of nine years' working on the Bavarian State Line indicate that 100 cubic feet or 2.486 cubic meters of the prepared turf of average quality and dryness, are equivalent to 312.5 kilograms of coke, or to 3.135 cubic meters of white firewood, *i. e.*, of wood principally of birch, beech and alder. Thus during this interval of working, the cost of firing with turf was about half that of coke (*in Bavaria*), and two-thirds that of wood. But taking everything into account, as derived from the accounts of the line for 1861-62, it may be shown that even this is too favorable, for that the fuel account per kilometer per engine stands thus:—

	Fired with Coal.	Fired with Peat.
Passenger Engines.	0.166f.	0.172f.
Luggage Engines..	0.249f.	0.207f.

It is thus, though rather cheaper than coal for slow traffic, a trifle dearer than coal for fast, and that even in Bavaria, where coal was then exceptionally dear.—*Practical Mechanics' Journal.*

RAILWAY IMPROVEMENT IN NEW YORK CITY.—The Legislature of the State of New York, at its last session, authorized the construction of a railway station on the Fourth avenue, to be used jointly by all trains arriving in this city from the north.—This station will extend from Forty-second to Forty-fifth street, closing Forty-third and Forty-fourth streets, and will occupy an area of about 800 feet in length by 300 feet in width, taking in for this purpose 150 feet on either side of the avenue. The Hudson river road is to be connected with the Harlem and New Haven track, and all the trains of these three roads are to be brought under one roof. The estimated cost of this improvement will amount to $1,000,000, and it is stated that the permanent way of these lines are to be so combined as to permit the freight carried over them to be all delivered at the large depot now occupying what used to be St. John's Park. The advantages which these arrangements will afford to travelers and the commercial community over the present disjointed state of city and country intercommunication, are apparent. —*Scientific American.*

STEEL RAILS.—Probably nothing is better established in railway practice than the superior economy of steel tyres, as compared with iron, even at twice the original cost per hundred weight. The wear of rails is less rapid than that of tyres, except where the traffic is incessant and enormous. Hence, probably, arises the nice calculation—never applied in the case of tyres—of interest and compound interest, as accruing upon iron and steel rails respectively.

It is now being industriously represented that the royalty on Bessemer steel rails is £2 per ton, and that this royalty will cease, with the expiry of the patent, in February next. The royalty is, and has all along been, £1 per ton only, and of this but 17s. 6d. will cease to be levied in February next.—Steel rails have hitherto been put down mainly on those portions of railways on which the traffic was unusually heavy, and as these portions have, for the most part, been already laid in steel, the necessity for the further use of steel may appear less urgent now than it did a few years ago; but it is none the less urgent where iron rails, in exposed situations, must now or soon be renewed. Rails that can be safely permitted to wear another year, ought, of course, upon every consideration of economy, to be left to fulfill their full service; but there are thousands of tons of iron rails, on our great lines of railway, which will have completely worn out this year and which must, therefore, be renewed before winter sets in. And as it is easy to prove that, under heavy traffic, the wearing value of steel, even at £12 per ton, is very much more, after allowing for the difference of cost, than £1 per ton greater than that of iron rails at £6 or £7, it would be anything but economy to put down iron rails again to last two, three or four years, merely to escape a moderate present royalty, and to take advantage of its diminished amount in 1871, '2 or '3. So far as extensive observations go, the wear of steel is from ten to twenty times that of iron, while as for breakages, the fractures of steel rails do not exceed one per cent of those of iron rails. In situations, then, where iron rails are not likely to wear longer than a year or two, it would manifestly be unwise policy to replace them with iron merely to avoid a few shillings extra royalty on steel. This point is, we think, too well understood to require any lengthened argument, and it is not, therefore, to be wondered at, that within so short a time of the expiry of the Bessemer patent, the steel rail mills continue, according to the current trade reports, to be very well employed.—*Engineering*.

THE READING RAILWAY SHOPS.—This company has the largest shops, foundries, and rolling mills in the city of Reading, and gives employment to over 2,000 men. The company makes its own locomotives, cars, and all other work necessary to equip and keep the road in running order. Two locomotives are made per month, but the demand for engines is so great that a contract has been made for twelve at the Baldwin Locomotive Works in Philadelphia. In the rolling mills sixty tons of rails are made each day, and in the two foundries 12,000,000 lbs. of castings per annum. The brass foundry yields 200,000 pounds of castings per year, and 1,000 tons of wrought iron are also made during the same period. The pay of the workmen in all the shops of the company amounts to about $85,000 per month.—*American Railway Times*.

FAIRLIE'S STEAM CARRIAGE.—The "cabbage garden" at Hatcham is likely to become as famous as the race course at Rainhill, only that there is no *race*, so dear to the heart of every Englishman, except a race against time. Mr. Fairlie has a combined engine and carriage, weighing but 13¼ tons empty, and capable of seating 66 persons, which is whisked around the Hatcham cabbage garden—upon a villanous permanent way, not exactly a circle, one-ninth of a mile in circumference, and having three quadrants of 50 feet radius. Seeing *is* believing, and we only regret that there is no Act of Parliament to compel every railway director and every railway Mephistopheles (the locomotive superintendent) to go to Hatcham and see. Thirty miles an hour and more has been accomplished, but we considered twenty-five preferable, and we stipulated for this, and no higher, speed when we sat foot upon the engine bogie. With the Field boiler there was no end of steam—160 lbs. per square inch—and the regulator could hardly be touched by the skillful hands of Mr. Clemenson without giving a jump to the whole affair almost enough to send us into centrifugal convulsions. The gentleman who, after first addressing the Institution of Civil Engineers, declared that the "theater" made 60 revolutions per minute during the whole period of his communication, would have been as much astonished at the circular movements of the little edition of a railway train at Hatcham. Round and around, four times round the cabbage garden, up and down gradient, and almost half a mile, was repeatedly done in one minute.

The merits of this system will not long want appreciation. Even the Ramsbottoms, the Armstrongs, the Stirlings, the Beatties, the Kirtleys, the Cudworths, the Cravens, the Johnsons, the Martleys, the Pearsons, the Connors, the Fletchers, must at last give in. The motion is more like sailing than riding, that is, the motion in the carriages. The "centrifugal convulsions" to which we have referred were generated only upon the engine bogie, and in the next carriage, this being the first of a certain number *in futuro*, the engine will be so connected with the carriage as to prevent any jerking or striking, at full speed, a curve of even three-quarters of a chain radius.

It is but just to Messrs. Brown, Marshalls & Co., to mention that the "train"—all in a single carriage—is the model of comfort and neatness. When we first saw the carriage, in the makers' factory at Birmingham, under a low roof, we took the impression that the compartments were cramped in the matter of space. But in the open air of the Hatcham cabbage garden we found, not alone by the sensation of comfort, but still more so by the act of measurement, that the seats were at least as capacious, and that for thick men, as any known near the Metropolis.

The railway company which first secures the exclusive use of Fairlie's steam carriage has dividends as good as declared for its shareholders.—But with one carriage there will be many, and let us hope that all the companies may, by these means, come round to dividend payments at last.—*Engineering*.

THE MANCHESTER N. H., LOCOMOTIVE WORKS have been very much enlarged, and six locomotives are turned out monthly. The works employ 400 men.

PACIFIC RAILROAD TIME TABLE.—The following statement of Time and distances is given by the *Western Railroad Gazette:*

	Miles.	Hours.
New York to Chicago, Ill.....	911	36½
Chicago to Omaha, Nebraska.....	491	24⅜
Omaha to Bryan.....	858	43
Bryan to Ogden, Utah.....	233	10¼
Ogden to Elko, Nevada, via Central Pacific R. R.....	278	12¼
Elko to Sacramento, Cal., via Central Pacific R. R.....	465	31
Sacramento to San Francisco, via Western Pacific R. R.....	117	3¼
	3,353	161¼

Thus a total distance of 3,353 miles is made, according to the present schedule time, in 6 days and 17½ hours, actual time, by a traveler's watch, from which we deduct 3¼ hours difference of time, when going West, leaving the apparent time consumed in making the trip 6 days and 14 hours.

At San Francisco the mails will connect with the various steamship lines running on the Pacific, and may be landed in Honolulu in 9 days from that city, or 15¼ days from New York. They can reach Japan in 19 days from San Francisco, or 25¼ days from New York, or 33 to 34 days from Great Britain—thus beating the British mails sent via Suez, three to four weeks. The trip between Yokohama, Japan, and either Hong Kong or Shanghai, is readily accomplished by the Pacific Mail steamships in from five to six days, which, added to the time in reaching Japan, will give the through time necessary to reach either of the above named ports of China.

The mails for Australia, it is thought, will hereafter go via San Francisco. as the Australian and New Zealand Steamship Company intend transferring the terminus of their line, which has been running from Sydney to Panama, so as hereafter to run from Australia to Taluti, thence to Honolulu, and thence to San Francisco, making 28 days schedule time, which will give us monthly mail to Australia in 34 or 35 days through time.

STEEL-CAPPED RAILS.—A paragraph has been going the round of the press, stating that the Hartford and New Haven Railway Company had ceased laying down steel rails, for the reason of their "stiff, unyielding character." As rail stiffness is what our engineers have long been striving for, the reason given was rather odd, to say the least. We have never found a rail too stiff for a thirty-two ton engine, going at speed, and probably no one else has. The section of rail should always be heavy or stiff enough to prevent any deflection when the driving-wheel passes between the sleepers; if not, the wheels are constantly running up and down short inclines, producing that unsteadiness of movement and pounding that is so destructive to both rails and wheels. The rail is nothing but a girder, and the more strong and stiff it is, the safer and better it is for every purpose. Any elasticity of the track should be applied in the superstructure below the rail. We understand that the Hartford Company has ceased laying down steel-capped rails for the reason that the officers desire to test their utility before further expense is incurred. They have some fifteen hundred tons in the track, and at present it is doing well. The principal objection urged against the iron rail covered with steel is, that the steel will flake off by wear. The makers, on the other hand, claim that their system of uniting the two is complete, and that the steel will adhere until worn off. The durability of steel-capped rails is a matter which requires more experience to determine, though a lot of Prussian make (Funcke & Elbers) laid on the Boston and Providence road are showing fine results. These rails are not made of Bessemer but of puddled steel, and the method of piling in manufacture differs from common practice, it being vertical instead of horizontal, so that the weld being perfect, any defect or want of homogeneousness in the material will show itself in the head by a depression, instead of flaking off or laminating is seen in many makes of iron rails. The Prussian rail can be cut and notched in the flanges without any fear of a succeeding fracture at the point cut, and there is equal security against fracture at the bolt holes for the fish-plates. We must confess to some doubt as to the wearing qualities of an iron rail with a Bessemer metal cap shrunk on around the head, the difficulty being in getting a good weld; but we understand that it has been done with promise of good results. Our railway companies are making money enough to allow them to make a fair trial of all the new devices and we trust that they will do so, so far as they can without impairing the safe character of travel.—*Railway Times.*

THE SWISS ALPINE RAILWAY.—Besides the great engineering triumphs of the nineteenth century—the Suez Canal and the Mont Cenis—another work of no less magnitude is now claiming universal attention, namely, the Mont Saint Gotthard Railway. After the Prussian and Italian ambassadors notified lately to the Swiss Confederation the material support of their respective governments towards that undertaking, a conference was assembled at Lucerne for the purpose of taking the initiative in the matter, and to arrange a financial programme. Dr. Alfred Escher, the eminent Swiss statesman and railway director, reported that of the necessary capital—6,500,000*l.* sterling—2,500,000*l.* will be found in Italy, 2,000,000*l.* in Germany, and 2,000,000*l.* in Switzerland, these sums being composed of 3,600,000*l.* subventions, 1,000,000*l.* in obligations, and the rest in shares, the greater portion of which has already been subscribed for in Switzerland.

In the construction of the Saint Gotthard line the project, adopted by the Italian commission, will be principally adhered to. This project includes a perfectly straight and nearly level tunnel of 9¼ miles in length, the northern tunnel mouth at Goeschenen will be 1,100 meters, the southern at Airolo 1,130 meters, and the tunnel summit 1,137 meters above sea level; and this tunnel the contractor of the Mont Cenis tunnel has offered to execute in eight to nine years, including steel rails, for the sum of 2,480,000*l.*

Another project, proposing a surface line, rising at the rate of 1 in 20, to 1,800 meters' height, has been condemned, as not affording that expeditious, safe, and economical working as the lower line with long tunnel. This consideration has carried all the more weight with it, as the future Swiss Alpine Railway will have to compete with the Mont Cenis, Brenner, and the French Mediterranean lines. It has been stated that on this latter line, having no steeper gradients than 1 in 200, the working expenses of one ton net are only one farthing per kilometer, while the carriage of one ton net on gradients of 1

in 20 would cost four times as much, or one penny per kilometer; and, moreover, the surface line being double the length of the lower line, the working expenses would accordingly be in the ratio of 1 in 8. The lines connecting the Saint Gotthard tunnel with the Swiss and Italian railway system will still, however, present some heavy gradients and sharp curves.

We understand the attention of the Saint Gotthard Commission has been directed to Mr. Fairlie's double-bogie engines, and that gentleman's plans have been regarded with much favor and interest.—*Engineering.*

ELECTRIC LIGHTS ON RAILWAYS. — According to the American journals a novelty in railway management is to be introduced by the Erie Company, who propose to illuminate the whole line of that road at night by electric lights at the ferries, in the tunnels, on all dangerous curves, and on every engine. Mr. E. C. Morse, who has charge of the matter, states that he has made several important improvements, among others a plan for preserving the carbon points from wasting away and keeping them for months in good condition, a self-sustaining battery, and an invention by which the turning of the wheels of the engine shall collect electricity for use in illumination. There will be a light at each end of the ferry, which it is believed will make a collision practically impossible on the darkest and foggiest night. Even with the diminution of light caused by the jarring of the locomotive, it is estimated that the head-lights will show the track to the engineer on a straight line for three miles. More welcome, however, than any announcement of material improvements would be a notification in the cause of public morality that the managers of this line could be brought to a condition of responsibility for the pecuniary claims of the shareholders.—*Engineering.*

SPEED AND POWER OF LOCOMOTIVES.—The *speed* of an engine depends on the rapidity with which its boiler can generate steam. One cylinder full is required for each stroke of each piston. Each double stroke corresponds to one revolution of the driving wheels and to the propulsion of the engine through a space equal to their circumference. Wheels seven feet in diameter pass over twenty-two feet in each complete revolution. To produce a speed of seventy-five miles an hour, they must revolve exactly five times in a second; and to effect this revolution, each piston must make double that number of strokes in that time, and consume ten cylinderfuls of steam. The *power* of an engine in drawing loads depends on the pressure of the steam, which is usually about 120 pounds on the square in. It is also limited by the adhesion between the track and the driving wheels, which is proportional to the weight pressing on the latter; so that instead of the weight being an obstacle, it is one of the principal elements of power. The tractive power of an engine of 40 tons, with 32 resting on the drivers would be about 4 tons —*American Artisan.*

NEW RAILWAYS IN THE UNITED STATES.—It is believed that at least 5,000 miles of new railroad will have been opened in the United States in the course of the year 1869. Already the returns show a mile to every 876 of the population.

THE READING RAILWAY CO. are making very superior iron rails at their own mill by simply putting plenty of work on the iron.

NEW BOOKS.

A PRACTICAL TREATISE ON MODERN SCREW PROPULSION. By N. P. BURGH, Engineer. London: E. & F. N. Spon, Charing Cross. 1869. New York: D. Van Nostrand, 23 Murray street.

Mr. Burgh's important treatise on the screw propeller, the publication of which in numbers was commenced nearly two years ago, now lies before us as a handsome volume. We have already referred at some length to the first chapters of the book, and it is therefore unnecessary now to consider their contents again. They consist, it will be remembered, essentially of an opening chapter by Mr. Burgh, and a historical introduction from the pen of Mr. G. B. Rennie, M.I.C.E., which is contained in seventeen pages. We are not aware of the existence of any historical notice of the screw propeller at once so short and so good, and having said this much we fancy we have said all that is requisite to indicate the character of the chapter. Starting from this point we find next a treatise or chapter—which the reader will—on the geometry of screw propellers in general, written by Mr. Burgh, and this is followed up by a history of the Griffith's propeller, written by Mr. Griffiths himself; a chapter on its geometry by Mr. Burgh, and one on the geometry of the paddle wheel by Mr. Barclay. Here we must stop for the moment, as we do not intend to publish a list of all the chapters in the book; the more important we shall refer to in their proper order as we go on. The distinguishing feature of the volume is, that a large portion of it has been written by men of enormous practical experience. Besides the chapter by Mr. Rennie already referred to, we find here distinct, compact, neatly written treatises, based on special points of practice, from the pens of such men as Mr. Griffiths, Mr. John Penn, Messrs. Maudslay and Field, Messrs. Dudgeon, Captain Symonds, Mr. Langdon, etc., etc. The book, as a whole, therefore, constitutes an encyclopædia of the screw propeller, possessing the immense advantage over all other works on the same subject that it is written not by one man, but by several who are specially qualified to express the most valuable opinions, and to supply the most valuable information which is attainable. This fact alone would suffice to establish the character of the volume as the best work in existence on the screw propeller; but, in addition to this, a single glance at the volume will show that it contains a set of engravings which are absolutely unique. They represent to a fair scale, not the screw propeller of the past, not the screw propeller as it exists in patent office specifications, not as it lies in the brains of inventors, but the screw propeller, and every detail connected with it, as it exists in the naval and mercantile marine of Great Britain, and as it has come from the hands of the very best mechanical engineers in the whole world. It would be quite possible to take these engravings into any drawing office, and to prepare from them a set of drawings by the aid of which the designs "depicted"—to use a favorite word of Mr. Burgh's—could be carried out in practice. This is the highest praise which any engraving can receive, and, knowing this, we award it cheerfully to Mr. Burgh's lithographs.—*The Engineer.*

THE TRUE BASIS FOR THE CONSTRUCTION OF HEAVY ARTILLERY. By LYNALL THOMAS. London: F. Taylor and Francis, Red Lion-court, Fleet street, 1869.

A Course of Six Lectures on the Chemical Changes of Carbon. By William Odling, M. B., F. R. S., Fullerian Professor of Chemistry, Royal Institution. Delivered before a Juvenile Auditory at the Royal Institution, Christmas, 1868–'9. With Notes by Wm. Crookes, F.R.S. London: Longmans, 1869. For sale by Van Nostrand's.

Dr. Odling's Christmas Course of Lectures for Juveniles, at the Royal Institution, were no doubt attended by some of our readers, who, though childhood's time is gone with them, consented under the circumstances to the imputation of being still only big boys. To these and to all others who were present at the delivery of the lectures, the permanent record of them by Mr. Crookes will, we are sure, be very welcome as a *souvenir* of some happily spent hours. To listen to a lecture in which the nature of some group of natural phenomena is set forth in a form clear and distinct to the entirely uninitiated by a master hand, has always been to us a keen pleasure. Dr. Odling possesses in a special manner the power of comprehensive exposition, which, united with enviable qualities of voice and manner, renders his teaching unusually attractive.

The title of this course of lectures—*The Chemical Changes of Carbon*—only imperfectly indicates their subject-matter. For the benefit of those—necessarily the great majority—of our readers who did not hear the lectures, we will briefly enumerate the principal matters touched upon the method of the course. Concerning the method, it is that of passing from one fact to some other to which it naturally leads, making the selection according to the object in view—that is to say, it is the common method of passing from the known to the unknown. This method has been, however, more extensively followed in these lectures than is usual. Mr. Crookes in his preface to the lectures says, and we quite agree with him:

"A remarkable feature in these lectures is the fact that every term made use of is defined as it occurs, and the oral definition is supplemented by a clear and decisive experimental illustration."

Of carbon itself, its three forms are described—namely, charcoal, graphite, and diamond, while of its compounds the three following are selected—carbonic gas (carbonic acid), carbonous oxide (carbonic oxide) and carbonic disulphide (sulphide of carbon), to which we might add marble from the considerable incidental notice it receives. The carboneted hydrogens are not studied. The physical and chemical properties of the atmosphere are pretty largely treated of, and the phenomena of combustion, oxidation and reduction, and of the diffusion of gases. The solubility of gases in liquids, the conversion of gases into liquids, and the reconversion of the latter into gases with the attendant phenomenon of the production of great cold are also fully illustrated. So, too, is the remarkable power of charcoal of absorbing gaseous bodies and withdrawing substances from solution.

Mr. Crookes has added an appendix of notes which is very useful. It might seem, at first, that a studiedly simple exposition ought to need no explanations, but it must be remembered that facts may be adduced to illustrate a point, and do so without ambiguity, at the same time that many particulars concerning them may receive no attention. But these facts after they have served the purpose for which they were brought forward, may still excite inquiry in the mind as to other things about them. Mr. Crookes' notes meet such a curiosity. To both the author and the editor of these lectures the friends of scientific education must feel themselves indebted.—*Scientific Opinion.*

The Soldier's Pocket-Book for Field Service. By Colonel G. J. Wolseley, Deputy Quartermaster General in Canada. For sale by Van Nostrand.

When, from time to time, we read of the publication of some military work of instruction, our first impulse is to look out in the Army List for a detail of the author's services, as we have a natural repugnance to wading through volumes of theories by men without war experience, who can only tell us what they think active service ought to be. Strange to say, almost all our military works are by such men. Many of their books are clever, and calculated to turn attention to military subjects, but all lack the clear ring of the practical about every page, bearing upon it unmistakable evidence that what it contains is either a personal theory or an extract from some foreign author. Whatever may be the shortcomings of the little handbook whose title heads this article, it is, at least, by one who is entitled to instruct us in war. Indeed, we know of no officer whose varied experience of active service and upon the staff fits him so well to be the author of such a work. It is intended, he tells us in his preface, for all three arms and for men of every rank; that the information it contains is the result of his own personal experience, and that it is, therefore, of an essentially practical nature. Throughout its pages there are extracts from our military regulations. It is a curious circumstance that there is but little in them which is applicable to war. If a man, from some unknown country, were to pore through them, it is possible he might imagine that to "march past in slow time" was *the* object for which our Army existed. War is, doubtless, alluded to occasionally, but only as a possible contingency. The consequence is, that when officers—even those of many years' standing—find themselves for the first time standing in front of an enemy, they are at a loss how to act. When such men are in command of regiments, unless they are of great common sense and sound judgment, the service must suffer from their endeavors to carry out in the field the routine of barrack life, to which noble (?) subject so much space is devoted in all our official regulations. Colonel Wolseley's handbook will be to all such men a *vade mecum* of great value.—*Army & Navy Gazette.*

Official Railway Manual of the Railroads of North America for 1869–'70; showing their Financial Condition, Mileage, Cost, Earnings, Expenses and Organizations; together with a List of the Railroads of the World. Compiled from Returns furnished by the Companies. By James H. Lyles, of Lindsay. Walton & Co., 56 and 58 John street, New York.

This is a complete directory in everything relating to the Railways of the United States. It contains, besides a full statement of the finances and engineering particulars of each road, full lists of the directors and all officers, statements of the rolling stock and locations of the shops, information as to the election of directors, and a great deal of miscellaneous information of value to persons in any way interested in railway matters.—*American Artizan.*

MÉMOIRE SUR LA COMPOSITION CHIMIQUE DES MONNERIES NÉERLANDAISES ET SUR LA VOLATILISATION DE L'ARGENT. Par A. D. VAN RIEMSDIJK, Docteur des Sciences. Pp. 38.

This is an abstract, reprinted and separately published, from the "Archives Néerlandaises," vol. iii, 1868. The larger work was written and published in Dutch early last year. It treats on a subject which can only satisfactorily be experimentally studied in a well-arranged Mint; and Dr. Van Riemsdijk, having that opportunity at Utrecht Mint, has thoroughly gone into matters with great zeal and industry. It will be clear, even to a casual observer, that divers chemical changes must of necessity occur to the alloys intended to be converted into coin during the many operations the alloy is submitted to before it leaves the works; it is simply impossible to melt together two metals and afterwards again anneal the partly rolled out bars, without some chemical change being called into play. The various changes and effects, also, of the blanching and cleaning of the alloys have been studied and experimented upon by the author. He has extended his experiments not only to Netherlands, but also to Belgian, French, Peruvian, Bolivian and Chilian silver coins. Gold coins are not made at the Utrecht Mint as current Netherland coins; hence no experiments were made with gold. The author has also investigated the capability of silver, both pure and alloyed, for absorbing and occluding various gases, especially hydrogen and oxygen gas. On the whole, those who work in silver on the large scale, and are interested in the real composition and constitution of the alloyed metal, will find in this paper many very interesting and useful hints, while assayers will certainly read with pleasure the information contained in these pages.—*Chemical News.*

BIBLIOTHÈQUE DES PROFESSIONS INDUSTRIELLES ET AGRICOLES. Edited by EUGENE LACROIX. Paris: 54, Rue des Saints-Pères.

This latest scientific publication of M. Eugène Lacroix—the indefatigable editor of the *Annales du Génie Civil* and the *Etudes sur l'Exposition*—is calculated to considerably enhance, not only his own already well-earned reputation, but also those of the able contributors by whom he has been assisted. Although the last-mentioned work (*Etudes sur l'Exposition*) is not quite finished, there being one more volume and the index unpublished, M. Lacroix has already published several volumes of a new work, entitled *Bibliothèque des Professions Industrielles et Agricoles*, which appears to embrace a large field of subjects. Thus the *Théorie Mécanique de la Chaleur*, which is translated from the German of Professor Clausius into French by Dr. Folie, is a very elaborate and complete treatise upon this difficult subject, but one which is most important to engineers and all interested in the economy of fuel. The second part of this treatise relates to the relation of the mechanical theory of heat to electricity. The next volume is upon a different subject, being an *Essai sur l'administration des enterprises industrielles et commerciales*, by M. Lincol, and will be found of great assistance to capitalists and managers of commercial enterprises of every description. A chapter entitled "Du rapport entre entrepreneurs et employés," in which the rights and obligations of employers and employed is considered, is well worthy the attentive perusal of both classes there indicated.—*The Artizan.*

PRACTICAL SPECIFICATIONS OF WORKS executed in Architecture, Civil and Mechanical Engineering Road-making and Sewerage; to which are added a series of useful agreements and reports. By JOHN BLENKARN, C.E., and Architect. Philadelphia: H. C. Baird, 1868. 8 vo. pp. 416.

Projectors of promising and important enterprises are not always wide-awake as to the financial details essential to the beginnings of carrying out. Here lies the wide gap between all the fine plans that are conceived, and their execution. There exists, accordingly, a class of more practical and less presuming engineers, who are sometimes called contractors and sometimes boss laborers, and whose care and specialty is to be clear on all questions of cost, and specification in detail. The present work is intended to assist engineers and architects with examples and methods, chiefly of specifications accompanied by plans, in the acquisition of such all-important practical points in the business of an engineer in full reputation and activity, as could otherwise be acquired only by many years experience.—*Mining and Scientific Press.*

ON MECHANICAL SAWS. From the Transactions of the Society of Mechanical Engineers, 1867. By S. W. WORSSAM, Jr. Illustrated by sixteen large folding plates. Philadelphia: Henry Carey Baird, Industrial Publisher, 406 Walnut street. Price $5.

The saw, there is good reason to believe, is one of the oldest of all the instruments used in the mechanical arts; and it has certainly played a more conspicuous part than any other in the history of civilization, though it is a subject on which little has been written. Mr. Worssam's book treats more particularly on the several kinds of saws driven by steam or other power—reciprocating, rotary and endless band. It discusses the various forms of teeth, with very copious illustrations; gives some valuable information on sharpening and setting, and on gauges, files and saw-sets. It also gives illustrations of saw sharpening machines. The work is a valuable addition to industrial literature.—*American Artizan.*

THE ELEMENTS OF THEORETICAL AND DESCRIPTIVE ASTRONOMY; for the use of Colleges and Academies. By CHARLES J. WHITE, A. M., Assistant Professor of Astronomy and Navigation in the U. S. Naval Academy. Philadelphia: Claxton, Remsen & Haffelfinger, 819 and 821 Market street.

This is a comprehensive though concise manual of the principles of astronomy, adapted to colleges and the higher grades of academies. It contains the latest information on every branch of the subject, including the recent interesting discoveries made by the aid of the spectroscope. We recommend it to those who wish to know the general principles and present state of the science of astronomy.—*American Artizan.*

THE OPERATIONS OF WAR. By Colonel EDWARD BRUCE HAMLEY, C.B. Blackwood. For sale by Van Nostrand, New York.

In closing a long review of this volume, the "Army and Navy Gazette" says: "We feel that Colonel Hamley has done good service by its publication; he has critically considered the revolution that has taken place within so brief a period in the operations of war; has weighed the consequences calmly and deliberately, and has offered his conclusions in a manner calculated to command attention."

THE RUTHVEN HYDRAULIC PROPELLER versus THE SCREW AND PADDLE. London: J. Haddon & Co.

This pamphlet, which the author has been too modest to own, proceeds from the "Ruthven Hydraulic Propeller office," and, as might be expected, is devoted to the task of proving that the Ruthven propeller is the best method of propulsion in existence. In order to accomplish this feat it has to be demonstrated that the Admiralty experiments with the hydraulic-propelled *Waterwitch* and the screw vessels *Viper* and *Vixen* were erroneous. This is done by asserting that in the *Waterwitch*, at the time of the trials there was an enormous leakage of steam, although Mr. Murray could not discover it. Considering the eminence of Mr. Murray in his profession, and also that the engines were one of Mr. Dudgeon's best jobs, it requires a considerable amount of credulity to accept the assertions contained in this pamphlet.—*The Artizan.*

A TREATISE ON ROPE MAKING, AS PRACTICED IN PRIVATE AND PUBLIC ROPE YARDS; with a Description of the Manufacture, Rules, Tables of Weights, etc., adapted to the Trade, Shipping, Mining, Railways, Builders, etc. By ROBERT CHAPMAN, formerly Foreman to Messrs. Huddart & Co., Limehouse, London, and Master Ropemaker of H. M. Dockyard, Deptford. Revised edition. Philadelphia: Henry Carey Baird, 406 Walnut street. 1869. Price $1 50.

Besides containing calculations and other information indispensable to the practical rope-maker who desires to thoroughly understand his business, this little book contains much that should be known in the various trades and professions in which cordage is used.—*American Artizan.*

THE MECHANIC. Vol. 1, No. 1. New York. C. Rogers & Co., 229 Broadway.

This a new weekly containing some dozen pages of matter and many wood cuts. The prospectus says: "That such a publication is required may be seen from the fact that, by the census of 1860, there were not less than 140,433 manufacturing establishments in the country, employing 1,311,246 persons, of whom 1,040,349 were males. Judging from the number of applications for patents there must be from 75,000 to 100,000 active inventors in the country, most of whose improvements are specially adapted to manufacturing processes and products."

THE MILLING JOURNAL AND CORN EXCHANGE REVIEW. New York: J. Q. Nolan & Co., 95 Liberty street. June, 1869.

This monthly journal has been enlarged and improved, and ought to be read with interest, we think, by all men in the department specially appealed to, and by artizans in general.

THE REPORT OF THE STATE ENGINEER OF NEW YORK ON RAILROADS FOR 1868.—We have in previous numbers of this Magazine quoted in full Mr. Sweet's able article on the manufacture and endurance of iron and steel rails and on permanent-way in general. Probably no governmental paper containing so much practical knowledge of the requirements of modern permanent-way, has ever been given to the profession. But this treatise is a very small part of the State report. The particulars of cost, management and working, for all the roads, are given in great detail.

MISCELLANEOUS.

COAL MINE DISASTERS IN THE UNITED STATES.—The more important recent disasters are thus recapitulated in the "New York Times":

In five years, there have been but six accidents worthy of mention, apart from the one which has just occurred; and two of these are of a nature not peculiar to mining. Thus, at Phœnix Colliery, Schuylkill Haven, on the 23d July, 1864, while a car loaded with miners was being drawn up the incline, the chain broke, the car was precipitated downward, and the twenty-one occupants of the car were killed. In July of the following year a flood occasioned by rain imprisoned the men employed in a coal mine at Mahoning, Ohio, from Friday till Wednesday; they were rescued by drilling another shaft. On the 3d April, 1867, an explosion fired the Clover Hill Mine, Pennsylvania, and about seventy miners—all that were at work—perished. In this case there were two shafts, both of which were closed with the view of controlling the fire. In November of the same year Pine Ridge Colliery, near Wilkesbarre, was closed to extinguish fire-damp; when opened, after some days, an explosion took place. At Diamond Mine, Scranton, in March, 1868, twelve men were killed by the breaking of a hoisting chain. The next casualty of which we have any record occurred eleven or twelve days ago in the Pine Ridge Colliery, in the Wilkesbarre neighborhood. An explosion of fire-damp gave rise to the fire at the entrance of the mine, in which thirty men were at work. Their extrication alive would seem, from the published statements, rather the result of Providential incidents than of any help which man was enabled to render.

And now comes the greatest calamity of all—the fire in the Steuben Mine, and the almost certain suffocation of more than two hundred miners. In this instance it is believed that fire was communicated from the ventilating furnace to the woodwork at the bottom of the shaft; the flames rushed upward with frightful velocity, and at the surface reached a mass of wooden buildings, which no effort could save. Burning timbers and rubbish soon filled the shaft, and, as no second outlet had been provided, the fate of all in the mine appears as certain as it is horrible. When at length a passage was obtained, it was only to find the accessible part of the mine filled with poisonous gases.

AVELING & PORTER'S STEAM PLOWS AND STEAM ROAD ROLLERS.—At Beauvais, France, June 30th, Messrs. Aveling & Porter, of Rochester England, and 43 Exchange Place, N. Y., exhibited their Steam Road Roller and their Steam Plow. The Emperor and Empress of the French were present and devoted an hour to the examination of Messrs. Aveling's machinery. The Emperor expressed himself highly gratified with the various machines and presented Messrs. Aveling with a gold medal for their Steam Road Roller, and another gold medal for their steam plowing machinery, which at the special request of the Emperor plowed up a portion of the highway, and without breaking any part of the machinery.

WOODEN GAS PIPES.—A firm in Oshkosh, Wisconsin, has contracted to make 1,000,000 ft. of wooden tubes to lay down in that city for gas pipes. They are made of timber 6 in. square, bored in the same way as pump barrels.

STEAMING AND ROWING—AN ENGINEERING PARALLEL.—One of the most remarkable features of modern steam navigation is the general substitution of the screw for the paddle. Indeed, the screw steamer has nearly driven its rivals from the stormy Atlantic, where the merits of submerged propellers and heavy spars are most manifest, and is fast chasing them from more pacific waters the world over. The "Persia," which but fourteen years ago was considered the perfection of naval architecture, was last year sold for £15,000, to be changed from paddle to screw. Just as the Cunarders were experimenting with their first screws, the new French line to this country was started with paddle ships. One of them, the "Washington," which formerly steamed ten miles an hour with 96 tons of coal per day, has since been fitted with screws, and now steams 11.8 miles with 83 tons of coal; and the new ships of all Atlantic lines are invariably propelled by screws.

The greater economy of the screw ship with a given speed and load, or her greater speed with the same fuel, are not due entirely to the fact that the efficiency of her propellers as compared with that of paddle-wheels is less impaired by the rolling of the vessel—not entirely to the fact that the screw steamer, by reason of the submersion of her propeller and its indepencence of the rolling of the ship, can carry more canvass and can sail on her beam ends as well as on an even keel, as far as applying the engine power is concerned. Nor does the superiority of the screw ship lie entirely in her greater capacity for stowage, by reason of the greater compactness of her engines, nor yet in the improvement of her machinery for generating, superheating, distributing and condensing steam, since all these may apply equally to the paddle steamer.

One of the notable differences between the new practice and the old, both in ships and locomotives, is the high speed of piston adopted in modern engines. The paddle engine is a great lumbering heavy machine, moving at the moderate speed suited to the paddle-wheel. The screw engine is compact, light and lively, and it pulls the quick stroke demanded by the screw. A horse power is 33,000 pounds lifted one foot in a minute, or one pound lifted 33,000 feet in a minute. Now the paddle steamer principle carried to excess would illustrate this law by lugging around the 33,000 pound weight, and lifting it a foot, while the screw steamer would be burdened only with the one pound, which it would lift 33,000 feet. The total power is the same, but while in the one instance, a large percentage of it is neutralized in carrying itself—in carrying the cumbrous enginery by which its great force works through a small space—in the other instance, the enginery is small and light, because it has only to transfer a small force through a great space, and speed does not weigh anything.

There are many illustrations of this law in practice. The old style of locomotives with immense driving wheels, big cylinders and ponderous parts, has given place to light-moving parts, small drivers and quick stroke. A small cotton cord running at 60 miles an hour through a machine shop does the work of cumbrous cranes crawling a few feet a minute.

This engineering law and these illustrations establish the correctness of the quick stroke adopted by the Harvard oarsmen as compared with the long, slow, beam-engine stroke of Yale. Speed is an element of power that weighs nothing. If some element that is ponderous is substituted for it, a part of the total power is lost in the machine itself. —*N. York Times.*

BROWN'S PATENT STOP VALVE, OR GATE.—This is a sliding valve differing materially from, and having many advantages over the wedge valve. It is simpler, stronger, more effective, less liable to leakage, and more easily repaired. Its essential feature is a compound lever brace, or toggle-joint, which acts at the center of the gate, and at nearly a right angle with it. The pressure of the brace is very powerful, and having a center bearing, is distributed equally at every part, forcing the gate firmly to its seat; thus preventing that unequal bearing and consequent leakage, which in wedging valves is incident to imperfect adjustment, uneven wear, &c. The brace, though pressing powerfully, is instantly and freely relieved, for it moves through an inclined groove, and has a rolling motion at each end, thus avoiding all danger of sticking, as in wedging valves. The brace effects great pressure, and consequent tightness, with far less friction and wear than is possible with wedging valves. The gate is held gently to its seat by ribs in the box, so that as it moves, it clears the seat of any foreign substances which might otherwise get between the gate and seat and cause leakage, as in wedging valves; these ribs also relieve the stem from too great strain upon it. The valve is easily repaired, for the gate, brace and stem can readily be removed from the box without disturbing the pipe.

The small sizes, of bronze, are made unusually heavy, to prevent twisting, and of the best steam metal. The iron gates are also very heavy, and of a cylindrical and spherical form, to resist great pressures, and to prevent springing and leakage. It is as cheap as any other sliding valve, notwithstanding its great superiority in principle, construction and action. It is used by many of the largest works in the country, and is conceded by the most eminent engineers and machinists to be one of the best valves known.

STEAM HAMMERS.—Messrs. Morrison & Co., of Newcastle-on-Tyne, some time ago made a very large steam hammer on their patent principle, for the Aboukoff Steel Works, near St. Petersburg. The piston and piston rod form, of themselves, the hammer, and thus fractures now and then occur. To renew the piston rod, or hammer head, in wrought iron, costs £3,000, or, in puddled steel, £4,000. Messrs. Thwaites & Carbutt, of Bradford, are about to alter this hammer, putting in new standards, with ordinary piston, piston rod, and "tup."

OLD AND NEW COAL.—Our attention has been lately drawn to a curious observation which stands, as yet, as a fact without a sufficient reason. In one case, where hard coal is used in large quantities for purposes of me re evaporation, it appears that some which has been kept on hand in open piles for five or six months, is less effective by from 13 to 15 per cent than that freshly mined. A similar result, corresponding even in the percentage of deterioration, appears in another report from a smelting furnace. The deterioration from decrepitation, caused by absorption of water, is of course well known, but does not seem to apply to these cases.—*Jour. Franklin Inst.*

WOODEN AND CONCRETE PAVEMENTS.—Mr. Julius W. Adams, Chief Engineer of the Water and Sewerage Commission, Brooklyn, recently made the following report to the Board, which was adopted:

"The Nicolson pavement is too well known to require comment. It is extending in use in the Western cities, and although from the nature of the material, it cannot be expected to last as long as stone, yet its other acknowledged advantages commend themselves to a large class of our citizens.

The A. Miller pavement possesses, in my opinion, peculiar advantages over the Nicolson, as will be explained more particularly and at length hereafter, and I think the Board will be justified in adopting it, whenever they may have determined to use wooden pavement, as being equal at least to the Nicolson.

The McKenzie pavement has some merit, but it has some of the defects of the Nicolson to a greater degree than the latter, which may prove in practice to counterbalance its other advantages. A practical test is needed before its claims to being an improvement on the first-named pavements can be admitted.

The Williams pavement has an advantage in that it is prepared to be laid on a bed of concrete. It comprises in fact the concrete and wooden pavements, with a consequently increased cost. The merit claimed in the key of bituminous concrete is a fallacy, in my judgment, and is so far an experiment that until tested in practice I could not recommend the adoption of the plan by the Board.

The Miller pavement, with inclined blocks, experience has shown to be inferior to plans with the piles placed vertically, and is probably the least to be commended of any plan submitted to the Board.

Of the concrete pavements I have no evidence that either the Fiske or the Scrimshaw has any advantages, the one over the other. This pavement is extending abroad, but it has the merit in France of being composed of the native asphalt, which is not found in our country; and the imitations of it, composed of tar and gravel, it is known are very inferior to the native material. Laid on the present cobble pavement, properly repaired, it may give good results. The Hoyt pavement is a mere experiment, and possesses no merit that I can perceive over the Fiske or Scrimshaw. Neither of this nor of the remaining plans submitted have I sufficient evidence before me to justify my recommending them to the Board at this time."

DIFFERENTIAL PULLEY BLOCKS.—Messrs. Tangye Brothers, Cornwall Works, Smethwick, produce in large quantities, as a special branch of manufacture, Weston's differential pulley blocks, of which since 1859 not less than 30,000 have been turned out here. These are the only pulley blocks yet made in which the weight is supported without risk of running down while the cord or chain is hanging loosely. The multiplication of power also can be carried to almost any extent with an exceedingly small amount of friction. These blocks, besides their extensive use in all warehouses and manufactories, have found several special applications. While recovering from his illness in 1865, the King of the Belgians was accustomed to ascend from one floor of his palace to another by means of these blocks, a suspended couch being provided, from which his Majesty, with very slight exertion, could raise or lower himself at pleasure. In a note to the inventor, General Garibaldi recommended their use for remounting artillery thrown down on the battle field. The watchman on the lofty fire observatory at Hodges' Distillery, in London, raises himself easily and rapidly to a height of 135 ft. At an *abattoir*, near Brussels, 120 pairs are used in hoisting and hanging the carcasses of the slaughtered beasts. Prince Napoleon in person purchased a pair at the Battersea Agricultural Show for use on board his yacht. In Borneo they are attached to trees overhanging the coast, for loading vessels. They are also largely used in Cornish mines. They suspend chandeliers in public saloons. They are fitted on board the Royal Oak and the other iron-clad steamers. They lift the top of wagonettes and coach-houses, and, in short, wherever lifts are required with complete security in raising and lowering, the differential pulley blocks are employed with obvious advantage.—*Cor. Engineer.*

THE PATENT LAWS.—Resolutions were recently passed by the Inventors' Institute of Great Britain, to the following effect: that the inventor was entitled to remuneration for his labor, expenditure and skill as much as the author or artist to copyright for his book or work of art; that capital would not be embarked in promoting inventions unless profitable return for such capital is assured by the operation of law, such as is done by the existing patent law; that a good system of patent law tends to foster the trade and industry of the country, and to maintain its industrial position against the active pressure of foreign competition; that working men are especially interested in supporting the present law, by which they can not only safely exhibit their inventions in public, but reap the fruits of improved education and increased application of inventions.

SHIPPING OF GREAT BRITAIN—In the year 1868, the registered shipping of the United Kingdom (exclusive of river steamers) employed in our home and foreign trade, comprised the unprecedented number of 22,250 vessels of 5,516,434 tons, employing 197,502 men, exclusive of masters, viz: 20,525 sailing vessels of 4,691,820 tons, employing 153,840 men, and 1,725 steam vessels of 824,614 tons, employing 43,662 men. At the end of the year there stood registered as belonging to the United Kingdom 28,444 vessels of 5,780,530 tons, viz: 25,500 sailing vessels of 4,878,236 tons, and 2,944 steam vessels of 902,297 tons. This is the highest tonnage ever recorded. There was built and registered in the United Kingdom in 1868, 879 sailing vessels of 300,477 tons, and 232 steam vessels of 79,096 tons.

WAVE POWER.—An engineer of New York proposes to employ the waves of the ocean as a motive power for running mills, factories, &c. His plan is to build on the beach (at Long Branch, Rockaway, or elsewhere) a dyke several hundred feet in length, against which the waves of old ocean are privileged to break as wildly as they will, but are not to be allowed to recede. In the sea face of the dyke are the openings of conduits which conduct the water to a reservoir within the dyke. A canal from the reservoir re-conducts the water, by a circuitous route, to the ocean, to turn on its way the wheels of as many mills as can be built on the canal banks.

DEEP SEA SOUNDINGS.—At a meeting of the New York Association for the Advancement of Science and Art, held June 14, Mr. Livingston Morse exhibited his recently invented device for taking deep sea soundings without the inconvenience and delay incident to the use of ordinary sounding lines. The apparatus is termed a "bathometer," and consists in a hollow cylinder of wood or sheet-metal containing a number of hollow glass spheres, which, being filled with air, constitute the floats by which the device is caused to return to the surface of the water after its descent to the bottom. The cylinder is ballasted in such a way that it will maintain an upright position in the water, and has a detachable weight affixed to its lower end. When dropped overboard, the weight carries the apparatus to the bottom, whereupon, by an automatic contrivance, the weight is detached and the cylinder rises to the surface. The time of ascent and descent being about equal and the rapidity of movement being ascertained by previous experiment, the period of submersion is a tolerably accurate index of the depth. The inventor, however, does not intend to rely upon this, but has provided the apparatus with a peculiar registering device by which the pressure of the water, and consequently the depth, is accurately recorded. The instrument is furthermore so contrived as to bring up a specimen of the bottom of the sea at the point where it struck.—*Am. Artizan.*

WATER DEPRIVED OF AIR—BOILER EXPLOSIONS.—In reference to the well-established fact that water, after having been deprived of air as much as possible, either does not boil at all when heated, or does so with violent, sudden starts and concussions, some experiments have been made by Kremers, who observed that, in order to assist in expelling air from water, the addition of spirits of wine, in the proportion of one part of the latter to three of the former, is very useful. He cautions against a danger which exists when such a mixture is heated too rapidly, since it is very apt to boil over, especially after a portion of the spirit has evaporated. It is rather curious that, though both the water and spirits of wine were pure, the mixture when boiling should assume a greenish-yellow hue, which disappears again on cooling. The boiling-point of the fluid easily becomes as high as 109°. As a result of a large number of experiments, the author finds that water, as fully deprived of air as possible, may be heated as high as from 180° to 200° C., without boiling permanently.—*Quarterly Journal of Science.*

A NEW FREEZING MIXTURE, which appears to be of considerable interest, has been described by Mr. Galletly. When citric acid and crystallized carbonate of soda, in powder, are stirred together, the mass gets into a pasty state, and in a short time becomes quite liquid. If equivalent proportions of the substance are used, the temperature falls from 60° F., to 8° F. The mixture, for a time, is full of air-bubbles, but soon becomes a clear, dense, syrupy fluid. The fluid obtained by mixing the powders becomes solid in a day or two standing in a corked jar. The solid mass has the appearance of set plaster of Paris or damp chalk. The addition of a very little water appears to prevent this setting into a solid mass; but the chalky-looking citrate lies a long time in cold water without being dissolved.—*Quarterly Journal of Science.*

PLATINIZING COPPER.—In order to obtain a platinizing fluid capable of platinizing copper, yellow metal, and brass, add to a moderately concentrated solution of chloride of platinum, finely powdered carbonate of soda until effervescence ceases, next some glucose, and afterwards just so much common salt as will cause a whitish-colored precipitate. When it is desired to apply this mixture for platinizing, the objects to be treated are placed in a vessel made of zinc and perforated with holes, the vessel is then placed, with its contents, for a few seconds in the mixture just described, which, just previous to using, should be heated to 60° C. On being removed from the zinc vessel, the objects are to be washed with water and dried in saw-dust.—*Quarterly Journal of Science.*

SELF-REGISTERING COMPASS.—An instrument of this description, devised by Captain Albini, of the Italian Navy, and constructed by Messrs. Elliot Bros., of London, was exhibited at the late Conversazione of the Institute of Civil Engineers. It consists essentially of a compass, with a card carrying types at its periphery in such a way that, by an attached clockwork, an impression may be made at stated intervals on a band of paper, from whatever type is over a certain point at these times. Thus clearly an almost continuous record of the ship's course may be automatically produced.

WATER BALLAST ROAD ROLLER.—Messrs. Ames & Barford, of Peterboro', England, are building rollers, water tight, so as to be filled with water to increase the pressure when necessary. Besides securing in one roller a one, two, or three-horse implement at pleasure, the increased weight is employed directly on the surface of the land, with the highest percentage of crushing power, yet without increasing the friction on the bearings (and consequently the draught of the implement), as is the case when the old clumsy plan of loading the frame is resorted to.

VENTILATION, FOOD AND HEALTH.—General Morin, in giving an account at the Academie des Sciences of the successful application of his ventilating apparatus in a large weaving factory employing 400 workpeople, and in which were lighted 400 jets of gas, observed that its advantage might be judged of from the fact that during October, November and December, 1867, when the ventilation was defective, only 15,000 kilogrammes of bread were consumed, while, during the same months of 1868, after it had been improved, 20,000 kilogrammes were required, being a gain of 25 per cent for the health and vigor of the operatives.

WASTED COAL DUST.—In Great Britain the quantity of coal dust remaining unemployed is calculated at 28,000,000 tons. Various methods have been attempted to convert it into useful fuel by compressing it into cakes, but the operation is not sufficiently remunerative. In Belgium they follow another plan, which seems to answer better. They mix coal dust with eight per cent of tar, and then press it into cakes, which are found to make excellent fuel for steam engines.

ARTIFICIAL LIGHTNING.—Professor Pepper has recently added to the apparatus of the Polytechnic Institution a monster induction coil, which furnishes a spark, or rather flash of lightning, 20 inches in length.